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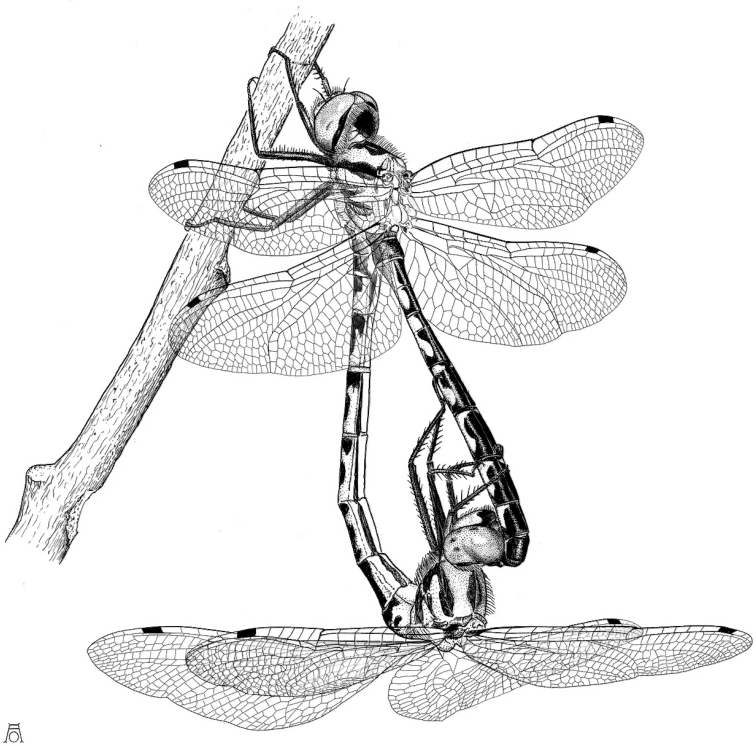

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NEW DATA ON *AELIOSOMA WEBERI* BAEHR, 1985 (HETEROPTERA: PENTATOMIDAE)

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Abstract

The first records for *Aeliosoma weberi* Baehr are given since its original description in 1985. This species is newly recorded from the Australian States of South Australia and Western Australia. Additionally, a teratological case of antennal oligomery is described.

Introduction

The Aeptini is one of 41 tribes currently recognised in the Pentatominae and currently contains 20 species in 8 genera (Faúndez and Rider 2018). The Aeptini has a disjunct distribution, including genera distributed in both Africa and Australia (Faúndez and Rider 2017).

Aeliosoma Baehr, 1985 is an enigmatic, monotypic genus of Aeptini, which stands out by having only 4-segmented antennae instead of the typical 5-segmented antennae found in all other members of the tribe (Faúndez 2017). *Aeliosoma weberi* Baehr, 1985 (Fig. 1), the only species placed in this genus, has not been treated since its original description. Only Cassis and Gross (2002) have mentioned it, in a Catalogue of Australian Heteroptera; they did not add any new information. The purpose of this contribution is to provide the first new distributional data for this species since its original description and to report a teratological case.

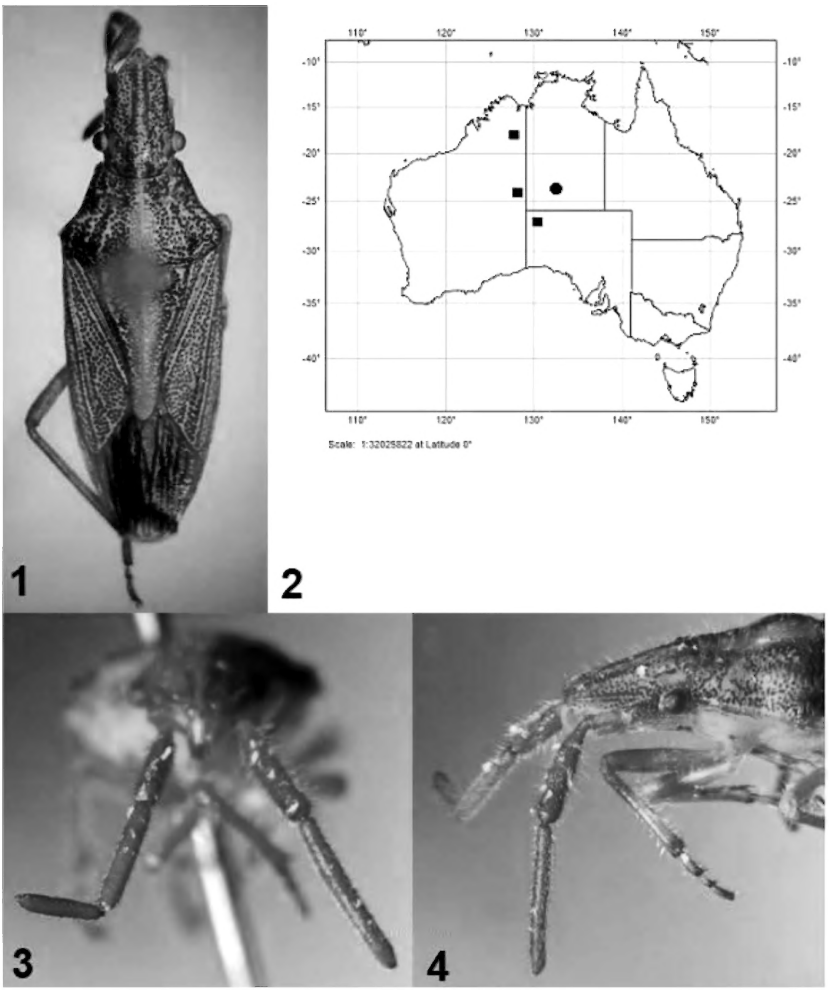
Material and methods

For the identification and systematics of the species, we follow Faúndez (2017) and Rider *et al.* (2018). In terminology and classification of the teratological case, we follow Štusák and Stehlík (1978) and Balazuc (1951). Photographs were taken with a digital camera adapted to a stereoscopic microscope. Material examined is deposited in the collection of the South Australian Museum, Adelaide, Australia. The map was developed with Panmap, Pangaea ®. All measurements are in millimetres.

Results

Baehr (1985) described *A. weberi* from Alice Springs, Northern Territory, which was the only known locality for this species until now. We here provide the first records of *A. weberi* from South Australia and Western Australia (Fig. 2).

Material examined: *A. weberi*: 11 ♂♂, South Australia, Mt Lindsay, 15.x.1976; 3 ♂♂, Western Australia, Gill Pinnacle, 5.ix.1966, Aitken & Tindale; 2 ♂♂, Western Australia, Flora Valley, 12.x.1953, Tindale.



Figs 1-4. *Aeliosoma weberi*: (1) male from South Australia, habitus; (2) distribution, circle = type locality, squares = new records; (3-4) teratological specimen: (3) frontal view of antennae; (4) detail of malformed antenna, lateral view.

In addition, one of the specimens from Mt Lindsay has an antennal malformation that is described below.

Simple antennal oligomery in *A. weberi* (Figs 3-4)

The left antenna is missing a segment, is reduced in size and the three remaining segments have different proportions from those of the right antenna, which is normal (Table 1, Fig. 3). The first two antennomeres

appear to be nearly normal. The third segment, however, appears normal (similar to the right third segment) on the basal three-fourths, but the distal one-fourth is more similar to the right fourth segment, including the shape, the type of pilosity and the punctation (Fig. 4). The rest of the specimen is normal.

Table 1. Measurements of the antennae of teratological specimen of *A. weberi*.

Antennomere	I	II	III	IV	Total
Left antenna	0.47	1.66	2.16	-	4.29
Right antenna	0.48	1.44	1.60	1.16	4.68

Discussion

Antennal malformations are among the most frequent teratoses in pentatomoid bugs (Faúndez *et al.* 2017). According to Štusák and Stehlík (1978), these might occur as a result of an injury during one of the juvenile stages or by a disease. In the case described here, the left antenna seems to have sustained damage during an early instar, losing a segment or more. Therefore, during ontogeny, the segments reorganised and adopted the shape and pilosity of the others (*e.g.* shape and pilosity of the third antennomere in this case). This response by the bug probably occurred in order to not lose some of the sensory properties of the lost antennal segments (Štusák and Stehlík 1978). It is the first oligomery reported in a pentatomid species with less than 5-segmented antennae. Also, it is interesting to point out that although there were changes in the relative lengths of the antennomeres, the width proportions (*i.e.* very thin first antennomere and the much wider remaining antennomeres) were preserved in this specimen. Thus, it is possible that instead of a full mutilation, this case might have resulted from losing only a part of the antenna during a very early instar, or it might have been produced by a disease or some type of mechanical pressure. As a result, during the ontogenic development the malformed antenna regenerated in a very functional way.

This is the third teratological case reported in the Aeptini; previously, two cephalic atrophies were described for *Hillieria acuminata* Distant, 1910 (Faúndez and Rider 2017). In that paper, it was pointed out that antennal malformations are probably less prone to occur in aeptines because most of the genera protect their antennae by folding them up under their bodies, within their thoracic sternal sulcus. *Aeliosoma weberi* does not fold its antennae in the resting position inside that sulcus. Since this is the first report of an antennal malformation within this tribe, this supports the hypothesis that antennal malformations are probably less prone to occur in aeptines.

Although new records and abundant new material of this species have been reported here, the female is still unknown.

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A NEW SPECIES OF *HOROUTA* KNIGHT (HEMIPTERA: CICADELLIDAE: DELTOCEPHALINAE) FROM NORTHERN AUSTRALIA

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Abstract

Horouta tropica **sp. n.** is described and illustrated from northern Queensland, including Torres Strait islands, and the Northern Territory.

Introduction

The Deltocephalini are grass-feeding leafhoppers defined primarily by the fusion between the male aedeagus and the connective that has its lateral arms closely aligned with each other throughout their length (Zahniser and Dietrich 2013). The Australian fauna is mainly distributed in the temperate parts of the country, the main genera being *Maiestas* Distant with nine species (four undescribed) plus an additional species on Norfolk Island (Webb and Viraktamath 2009), *Horouta* Knight with seven described species (Fletcher 2004, 2009a), *Warlucephala* Fletcher with three species (Fletcher 2006) and *Alodeltocephalus* Evans, also with three species (Fletcher 2009b). The genus *Loralia* Evans was transferred from the Deltocephalini to the Athysanini by Zahniser and Dietrich (2013) but its tribal affinities remain uncertain. There are also three Australian species that erroneously remain in the Palaearctic genus *Deltocephalus* Burmeister. Here, another species of *Horouta* is added to the Australian fauna from the tropical northern parts of Queensland and the Northern Territory.

Material and methods

The specimens used for this study were prepared for genitalia examination by maceration of the whole abdomen in 10% KOH heated on a warm hotplate for a few minutes, washed three times in water and examined in glycerine. After examination, the abdomen was stored in glycerine in a microvial attached to the specimen pin. Morphological terminology follows Zahniser and Dietrich (2008). The habitus photographs were taken with a Q-Imaging digital camera on a Leica M165C stereo microscope, captured in Q-Capture Pro 7 (SciTech P/L) and compiled in Auto-Montage Pro (Synoptics Ltd). The resulting images were improved and prepared as plates using Adobe Photoshop CS3.

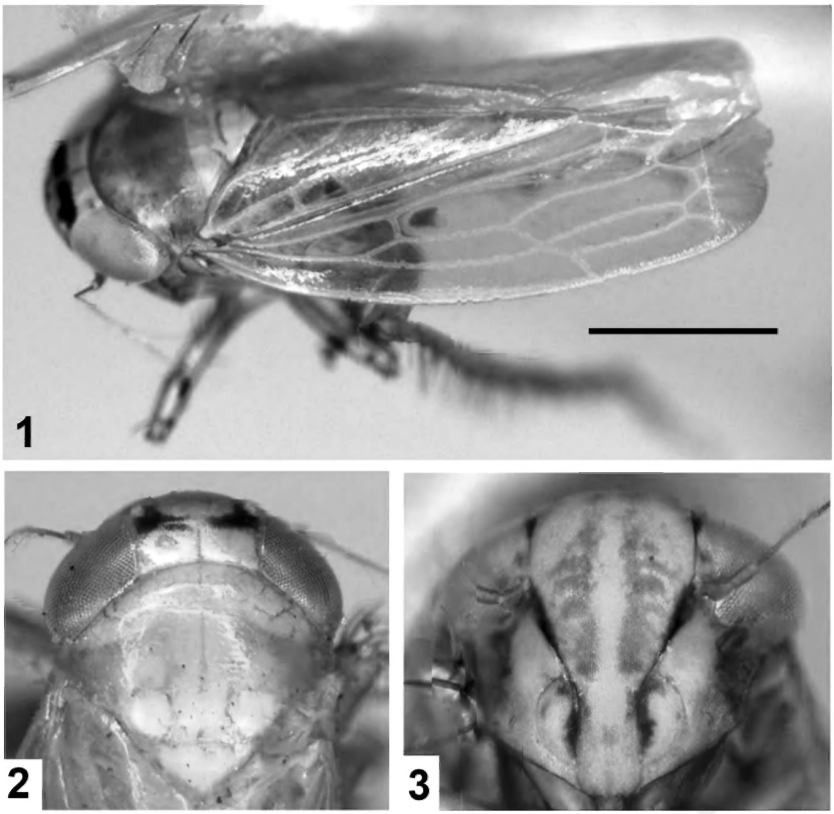
Abbreviations for repositories are: ASCU – Biosecurity Collections Unit, Orange; BPBM – B.P. Bishop Museum, Honolulu; QDAF – Queensland Department of Agriculture and Fisheries, Brisbane; QM – Queensland Museum, Brisbane; UQIC – University of Queensland Insect Collection, now housed in QM.

***Horouta tropica* sp. n.**

(Figs 1-13)

zoobank.org:act:89A12ABB-6CD4-40DF-B1B4-8F5B5FD2A6CB

Material examined. Holotype ♂, AUSTRALIA (QUEENSLAND): Murray Island, Torres Strait, 29.v-3.vi.1985, Donaldson & Hamacek, at light, ASCTHE035489 (QM - T244510). *Paratypes*: QUEENSLAND: 1 ♂, St Pauls, Moa Island, 12.ii.1986, Houston & Hamacek (QDAF); 2 ♂♂, same data as previous but 10-16.ii.1986, at light (QDAF); 3 ♂♂, same data as previous but 10-18.ii.1986 (QDAF); 1 ♂, Mitchell River mission, 31.iii.1960, E. Marks (UQIC); 1 ♂, Bamaga, 10.53S 142.24E, 5-12.xii.1986, Houston & Sadler, malaise trap (QDAF); 1 ♂, Sky Window Lookout, Eungella, W. Mackay, 8.iv.1976, I.D. Galloway (QDAF); 1 ♂, 13 km up Davies Creek Rd, via Mareeba, 21.xii.1984-7.i.1985, Storey & Titmarsh, malaise trap (QDAF); 2 ♂♂, Murray Island, 29.v.-3.vi.1985, Donaldson & Hamacek, at light (QDAF). NORTHERN TERRITORY: 2 ♂♂, Maningrida, Arnhem Land, 20-21.iii.1961, L. & M. Gressitt (BPBM).

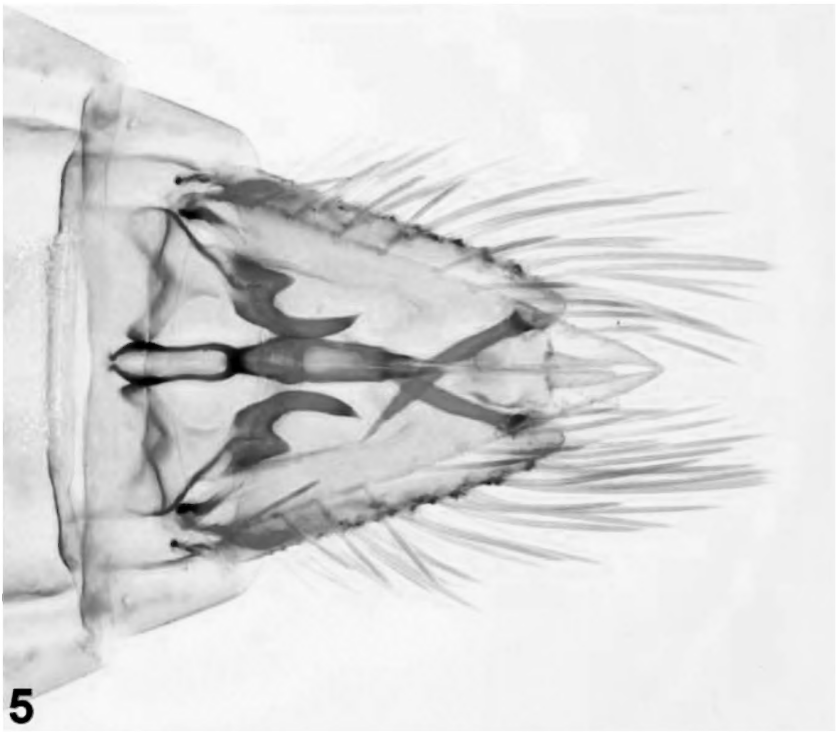


Figs 1-3. *Horouta tropica* **sp. n.**: (1) habitus, scale line = 1 mm; (2) dorsum; (3) face.

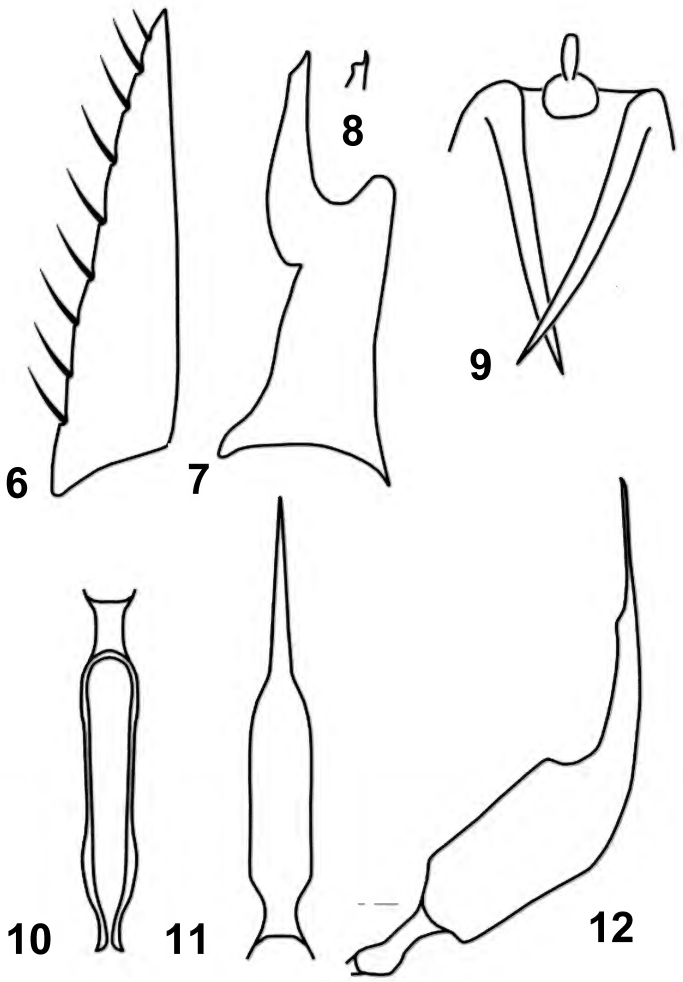
Description (Figs 1-3). Length: males (N = 14) 3.4-4.0 mm (mean 3.79), females unknown. Colour pale testaceous with dark brown transverse marking across anterior part of vertex, sometimes divided medially, small spot at base of third preapical cell, dark markings subapically on fore and mid femora and bases of hind tibial spines. Face (Fig. 3) broad with wide genae and small lora well separated from margin of maxillary plates. Clypellus with sides diverging almost to apex, then narrowed slightly. Frontoclypeal suture visible at extreme sides only. Frontoclypeus wide, tapered from apex of head to anteclypeus. Vertex rounded into face, of even width throughout, about twice as wide as long with occipital suture extending almost to front of head. Pronotum about twice as long as vertex, vaguely transversely rugulose. Tegmen with third preapical cell open basally and crossvein near base of clavus between inner claval vein and suture. Profemur with AV row of small stubby setae extending almost entire length of femur, AM1 present and intercalary row with 8 elongate macrosetae. Metafemoral setal formula 2+2+1 with macrosetae long, strong and prominent. Metatibia with dense macrosetae on all edges with macrosetae of row PD about twice length of macrosetae in other rows.

Male genitalia (Figs 4-12). Pygofer narrow in lateral view with basolateral membranous cleft present and dense forest of long setae on ventroapical half. Apex truncate bearing lateral processes that are elongate, linear, apically acute and slightly curved, mounted on internal side of apex on each side and extending ventromedially almost to opposite side of pygofer anterodorsally to the aedeagal shaft, the two processes crossing each other at about 3/4 of their length. Tenth segment attached inside apical aperture of pygofer. Subgenital plates elongate, narrow triangular to acute apex, bearing single line of 7-9 macrosetae along lateral margin, the distal one being half the length of the remainder. Paramere short with bluntly acute preapical process and apical process evenly tapered, extended posteriorly to apex, which is slightly obliquely truncate. Aedeagus simple, lacking processes; shaft in posteroventral view expanded from base, then tapered to long fine apex; shaft in lateral view with broad basal section over about 1/3 length, then abruptly narrowed to finely tapered acuminate point beyond preapical dorsal gonopore.

Comments. This species is placed here in *Horouta* but differs from other species in the genus in the rounded apical margin of the head, vertex of even length throughout, diverging lateral margins of the clypellus and lack of lateral processes on the aedeagus. In addition, all known specimens of *H. tropica* are macropterous, while most of the other *Horouta* species are also known to have brachypterous or semibrachypterous forms (Fletcher 2004). The presence of prominent processes on the pygofer is not a feature of *Horouta* generally, although *Horouta spinosa* Fletcher does have similar structures on the pygofer.



Figs 4-5. *Horouta tropica* **sp. n.**, male terminalia: (4) lateral view; (5) ventral view.



Figs 6-12. *Horouta tropica* **sp. n.**, male genitalia: (6) subgenital plate; (7) paramere, ventral view; (8) tip of paramere, lateral view; (9) pygofer appendages, posterior view; (10) connective, ventral view; (11) aedeagus, posteroventral view; (12) aedeagus, lateral view.

Etymology. The species name reflects the distribution of this species in the tropical north of Australia, whereas the other species of the genus have more southerly distributions.

Distribution. Recorded from northern tropical areas of the Northern Territory and Queensland, including the Torres Strait islands Murray and Moa (Fig. 13).

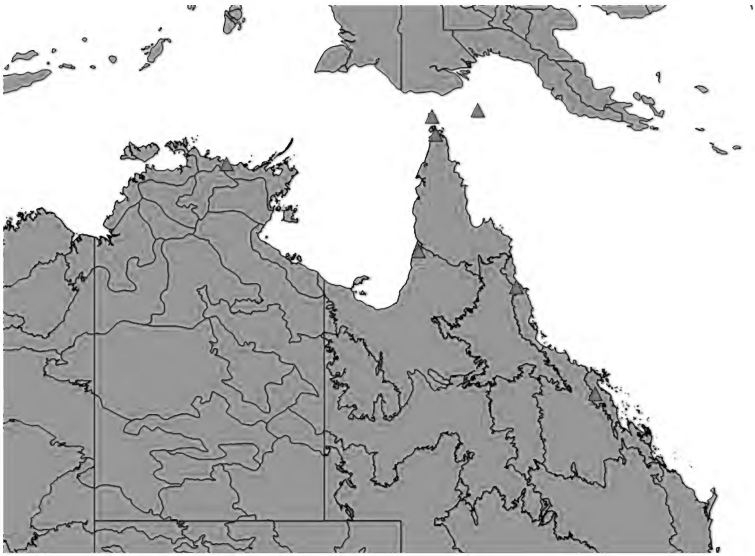


Fig. 13. Distribution map for *Horouta tropica*.

Discussion

The addition of *Horouta tropica* to the Australian fauna is significant because it adds a tropical element to a genus that is otherwise distributed across the temperate zone. The distribution of *H. tropica*, including islands in Torres Strait, raises a question about the representation of the Deltocephalini in New Guinea. Webb and Viraktamath (2009) recorded two species of *Maiestas, M. subviridis* (Metcalf) and *M. knighti* Webb & Viraktamath, from Papua New Guinea. Fletcher (2009b) listed four species of *Deltocephalus* from the eastern islands of Indonesia and *Maiestas dorsalis* (Motschulsky) from numerous localities in SE Asia and from Australia but not from Indonesia or New Guinea. It is probable that *M. dorsalis* occurs in New Guinea and it is also likely that there are species of *Horouta* in New Guinea. However, a sweep of grassland in Port Moresby revealed specimens of *Cofana* Melichar (Cicadellinae: Cicadellini) and Delphacidae but no Deltocephalini. Wilson (1983) recorded the genus *Paramesodes* Ishihara in New Guinea, based on female specimens that he was unable to identify to species. *Paramesodes* was included in the Deltocephalini by Zahniser and Dietrich (2013). This leaves the New Guinean fauna relatively depauperate in Deltocephalini, with only three species in two genera recorded from the island.

Acknowledgements

Taxonomic research on the Australian Deltocephalinae by the author has been supported by funding from the Australian Biological Resources Study, now part of the Commonwealth Department of the Environment and Energy.

Access to facilities at the NSW Biosecurity Collections Unit in Orange is gratefully acknowledged. I thank Lauren Drysdale of ASCU for the automontage images in Figures 4-5 and Dean Woruba for conducting the trial sweep of grassland in Port Moresby looking for Deltocephalini.

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DESCRIPTION OF THE LARVA OF *TERMESSA SHEPHERDI* NEWMAN (LEPIDOPTERA: EREBIDAE: ARCTIINAE: LITHOSIINI) FROM SOUTHEASTERN NEW SOUTH WALES

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Abstract

Nine late instar larvae of the Shepherd's Footman moth, *Termessa shepherdi* Newman, were collected from a lichen-covered rock outcrop in a montane environment, southeastern New South Wales. A rearing method is explained and immature stages are described and illustrated.

Introduction

The Arctiinae moths are commonly known as footmen, lichen, tiger or wasp moths and contain 3 tribes, the Lithosiini, Arctiini and Syntomiini. The Australian tribe Lithosiini was revised by Meyrick (1886) and Turner (1940) and contains 75 genera (Edwards 1996). The genus *Termessa* Newman, 1856 is endemic to Australia and contains 12 species (Edwards 1996).

The only previously published record of the biology of an Australian species of *Termessa* was of *T. nivosa* (Walker, 1865), of which larvae were found under bark of eucalypts but no host plant was mentioned (Froggatt 1907). Several late instar larvae of *T. shepherdi* were discovered beneath foliose lichens, which covered loose sheet joints that rested on the surface of large granite boulders (Fig.1), in a montane environment east of Hoskinstown, southeastern New South Wales. This larval description adds to our understanding of Lithosiini, a tribe with near worldwide distribution.

Materials and methods

Nine late instar larvae were collected in the South Black Range, east of Hoskinstown, at 1130 m (GPS: 35º24'45.58"S, 149º32'07.93"E), on 10 August 2014 from under a sheet joint of a lichen-covered granite outcrop (Fig. 1) and from similar, nearby boulders. The different lichens growing on the boulders were collected, as well as a small amount of soil from the base of boulders that included some dry leaf litter. This soil-leaf mix was added to a plastic container and the lichens and larvae placed on top.

To regulate humidity, a perforated paper top was modified in such a way that it could be removed easily. Water was sprinkled on the lichen to simulate rain every second day; this softened and expanded the lichen and appears to have triggered a feeding response in the larvae, evident from larval faecal pellets that accumulated on a piece of paper placed in the container. The larvae were not observed feeding, always remaining hidden by day. Pupation occurred in a loosely formed cocoon (Fig. 6).

A larva was preserved in KAA (a mixture of kerosene, acetic acid and ethyl alcohol described by Common 1990) for several days before being placed in a 4:1 mixture of 100% ethanol and glycerol for long-term storage. The

preserved larva was described and illustrated, with terminology following that of Halbeck (1987). Here, the terms 'multiordinal' and 'uniordinal' are used as in Nielsen and Common (1991). Setal mapping was not done because of the numerous undiagnostic secondary setae. Specimens were examined using a Leica M80 microscope with overhead LED lighting.

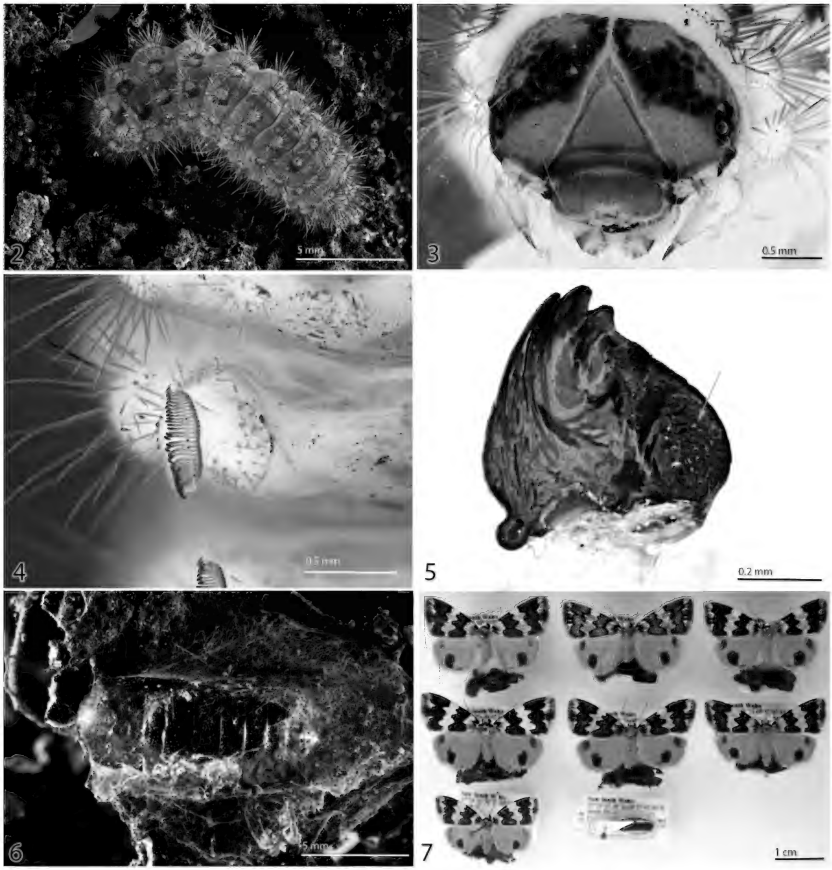
A late instar larva was added to the Lepidoptera larval collection (#4059) of the Australian National Insect Collection (ANIC), as well as an intact pupa placed in a pinned gelatin capsule. Larval and pupal exuviae (with cocoon) were carded on the pin of each adult. A dissected mandible was also carded. Specimens placed with the ANIC have the same label information as that of the late instar larva specimen, except for pupation and emergence dates.

Fig. 1. Lichen-covered granite boulder with loosely fitting joint sheets where *Termessa shepherdi* larvae occur.

Material examined. Larva: New South Wales, South Black Range, 1130 m, 35°24'45.58"S 149°32'07.93"S; under lichen-covered granite sheet joint. Collected: 10 August 2014, D.J. Ferguson, (ANIC_31:036146).

Adults: male, pupated, 23 August, emerged: 3 October 2014, (ANIC_31:036147); male, pupated: 22 August, emerged, 5 October 2014 (ANIC_31:036148); male, pupated, 23 August; emerged: 5 October 2014 (ANIC_31:036149); male, pupated: 22 August; emerged: 4 October 2014 (ANIC_31:036150); female, pupated: 23 August; emerged: 3 October 2014 (ANIC_31:036151); female, pupated: 30 August; emerged: 6 October 2014; additional on pin: carded mandible, (ANIC_31:036152); female, pupated: 27

August; emerged: 9 October 2014 (ANIC_31:036153); pupa and larva exuviae in separate pill capsules; pupated: 29 August 2014, mandible dissected and carded, (ANIC_31:036154).



Figs 2-7. *Termessa shepherdi* Newman: (2) last instar larva; (3) frontal view of larval head; (4) uniordinal crochets in a mesoseries on proleg A5; (5) mandible with large mola indicated by arrow; (6) pupa in loosely woven cocoon; (7) adults – note wing pattern variation. Scale as indicated.

Description

Larva (Fig. 2). Late instar larvae measured 1.5 cm. Head (Fig. 3): yellow-brown with blackish brown, blotchy, irregular-shaped band extending narrowly from epicranial notch along eye margin, broadening medially then narrowing lateroventral to surround stemmata. Frontoclypeus as wide as high, with apex approximately half the distance between clypeus and epicranial

notch; ecdysial lines cream-edged, apically meeting dorsad to frontoclypeus apex at a distance equal to the width of the clypeus. Six stemmata arranged on lateroventral surface of the eye. Mandible (Fig. 5) with three anteroventral teeth; with large conspicuous mola on basal, inner face (indicated by black arrow). Antenna short and cylindrical, basally yellow-brown; apically whitish; small dorsomedial bulging process with short, tapered projection at its apex; two short, hair-like projections on ventrolateral edge and another short and more robust on inner lateral edge. Thorax: legs with tibiae brownish cream and dark brown apical claws. Abdomen: slightly dorsoventrally compressed, brownish cream in colour, with broad, slightly darkened longitudinal dorsal stripe; 4 longitudinal rows of verrucae on each side; 3 dorsal rows edged with irregular black markings; first lateral row of verrucae dorsad of the coxae all without irregular marginal markings. Each verruca supports 35-40 light brown spines, darkened apically; each approximately equal in length to width of verruca, all with several untidy rows of blackish, outwardly directed barbs; the 2 rows of verrucae dorsal of the coxae have some longer spines nearly twice length of those of dorsal verrucae. Spiracle on abdominal segment 1, positioned on anteroventral margin, comparatively large, round, darkly sclerotised and raised above surface; spiracles on abdominal segments 2-7 comparatively small, darkly sclerotised and raised as tubes 1.5 x the diameter above surface; all positioned on posteroventral margin of verrucae except that on segment 7, which is positioned on ventromedial margin; segment 8 spiracle relatively large. Abdominal segments 3-6 with prolegs all of similar size, each terminating with mesoseries of 30-32 uniordinal crochets (Fig. 4); abdominal segment 10, claspers similarly with a mesoseries of 30-32 uniordinal crochets. Abdominal segments 6 and 7 without glands.

Pupa (Fig. 6). Length 9 mm; six pupae were dark brown in colour and one was slightly paler.

Comments

Termessa shepherdi larvae have uniordinal crochets, an unusual condition in the Lithosiini, which typically have multiordinal crochets (Halbeck 1987). Species with uniordinal crochets usually lack verrucae and instead have a single seta arising from a pinaculum (Halbeck 1987). *Termessa shepherdi* differs by having numerous setae arising from rows of verrucae. Nevertheless, *T. shepherdi* clearly falls within the Lithosiini because of the conspicuous, large mola on the basal, inner face of the mandible (Fig. 5). This is a diagnostic feature of the Lithosiini that is absent in the Arctiini and Syntomiini (Halbeck 1987).

The pupation duration ranged between 37 and 44 days, averaging 41.7 days (n = 7). There are notable differences in forewing patterns of the adults that emerged from larvae collected from the same location (Fig. 7).

Acknowledgments

I thank Chris Manchester for the photographs and preparing the image plate, Andres Zwick for suggesting sprinkling water on the lichen every second day to trigger a feeding response and for reviewing the pre-submission manuscript and Ted Edwards for reviewing an earlier version of the manuscript (all at CSIRO National Research Collections Australia). I also thank the New South Wales National Parks and Wildlife Service for supporting this study (NSW license # SL100528).

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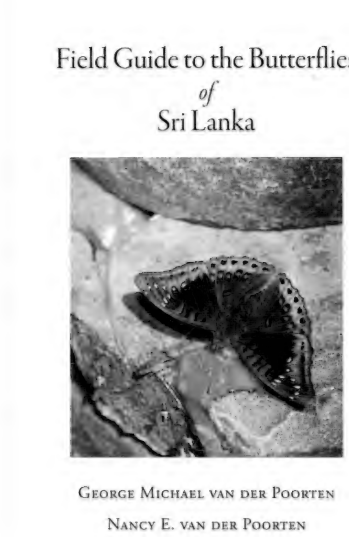
BOOK REVIEW

Field guide to the butterflies of Sri Lanka by George M. and Nancy E. van der Poorten. Lepodon Books, 2018; vi + 250 pp. Price $US 28. ISBN 978 1 771136 052 (paperback). Available from the authors at *lepodonbooks@gmail.com*

Following the notable success of their recent, lavish handbook to the butterflies of Sri Lanka (van der Poorten and van der Poorten 2016), the same authors have now produced a condensed, pocket-sized version of the same for use in the field. With a slim duodecimo (12 cm x 19 cm) format weighing just 386 g, the book is a model of compactness. It slips easily into a roomy pocket, yet preserves much of the philosophy of its larger predecessor, *i.e.* to show butterflies as they appear in nature and to provide information on their ecology and behaviour.

Sri Lanka is home to 248 butterfly species, 31 of them endemic to the island. Within a relatively small geographical area is found a wonderfully rich cross-section of the Oriental Region fauna, with almost all iconic genera represented. It is arguably one of the best introductions to this regional fauna one could have, as a large proportion of life histories are well known and one avoids the confronting diversity found, for example, in Borneo, where there are 88 species of *Arhopala* and many other mega-diverse and/or difficult groups. In Sri Lanka there are five species of this genus, just one more than in Australia.



The book serves primarily as a field identification guide. It illustrates all species presently known from Sri Lanka, with over 1154 thumbnail photographs of adult butterflies in life, depicting uppersides and undersides and, where necessary, both sexes. Difficult genera, such as the lycaenids *Spindasis* (7 spp) and *Jamides* (5 spp) and the hesperiids *Borbo*, *Parnara*, *Pelopidas* and *Suastus* (together 7 spp) are supplemented by keys and close-up photographs of diagnostic details, which are elsewhere clearly arrowed where necessary. In short, the book is extremely usable and fulfils its primary aim of field identification admirably.

For the entomologist or amateur naturalist in Sri Lanka, field identification is critical as collecting is totally banned and we are told it is illegal even to carry a net; hence, being able to identify species with binoculars and photographs is an essential skill. This book is designed with this in mind. Species accounts include concise notes on ecology, flight period and behaviour that help with field identification. Every species is provided with a distribution map, either in the main text or in an appendix. Information is provided on larval host plants and preferred adult nectar sources.

In summary, the book is exceedingly useful and a must-have for anyone visiting Sri Lanka. It is also a very neat and concise summary of the butterfly fauna of the island and well worth having as a basic reference, although its main purpose is to supplement the earlier, larger handbook. I strongly recommend this field guide to anyone with a serious interest in butterflies.

Reference

van der Poorten, G.M. and van der Poorten, N.E. 2016. *The butterfly fauna of Sri Lanka*. Lepodon Books: vi + 412 pp.

Reviewed by Albert Orr

A REVIEW OF THE SUBGENUS *ZEUGODACUS* HENDEL OF *BACTROCERA* MACQUART (DIPTERA: TEPHRITIDAE: DACINAE): AN INTEGRATIVE APPROACH

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Abstract

The *Bactrocera* Macquart subgenus *Zeugodacus* Hendel is reviewed using morphological, biological, biogeographical and molecular data. As a result, three subgenera are recognised. *Zeugodacus* s.s. [= *Pacifodacus* Drew, *Papuodacus* Drew and *Niuginidacus* Drew, **syns n.**, plus *Hemigymnodacus* Hardy] contains 60 species that are known or suspected to breed in the flowers of Cucurbitaceae. *Javadacus* Hardy is redefined to contain 85 species known or suspected to breed primarily in the fruit of Cucurbitaceae and includes the major pest species *B. cucurbitae* (Coquillett), *B. tau* (Walker) and *B. depressa* (Shiraki). *Capparidacus* **subgen. n.** is proposed for six species (*B. fereuncinata* Drew & Romig, *B. gavisa* (Munro) [type-species], *B. isolata* (Hardy), *B. juxtuncinata* Drew & Romig, *B. ujungpandangiae* Drew & Romig and *B. uncinata* Drew & Romig) known or suspected to breed in the fruit of Capparaceae. *Bactrocera* (*Sinodacus*) *quasiinfesta* Drew & Romig is transferred from subgenus *Zeugodacus* and a revised definition of *Sinodacus* Zia is provided. Keys to subgenera of the *Zeugodacus* group and species of *Capparidacus* and *Sinodacus* are included. An evolutionary scenario is discussed.

Introduction

This paper reviews the Indo-Australian subgenus *Zeugodacus* Hendel of *Bactrocera* Macquart, which belongs in the *Zeugodacus* group of subgenera as defined by Drew (1989). Based largely on molecular evidence, the currently recognised subgenus *Zeugodacus* s.l. is divided into three separate subgenera – *Capparidacus* **subgen. n.** plus the redefined subgenera *Zeugodacus* s.s. and *Javadacus* Hardy. As a result, the largely Papuan subgenera *Pacifodacus* Drew [= *Sinodacus* Groups C and D of Hancock and Drew (2018b)], *Papuodacus* Drew and *Niuginidacus* Drew are placed as **new synonyms** of *Zeugodacus* s.s., together with *Hemigymnodacus* Hardy, synonymised by Hancock and Drew (2018b). For detailed morphological descriptions and illustrations of the 151 included species see Drew (1989), Drew and Romig (2001, 2013), White and Evenhuis (1999) and Zhou *et al.* (2013) and for an illustrated key to South-East Asian species see Drew and Romig (2016). All species included here were placed in genus *Zeugodacus* by Doorenweerd *et al.* (2018) but are treated here under *Bactrocera* for reasons indicated in Hancock and Drew (2018b).

Although molecular evidence is not always totally reliable, acceptance or rejection of it is not an all-or-nothing situation. Molecular studies are becoming increasingly informative, with many of the clades produced being well supported and not falsified by morphology, biology or other molecular evidence. Such clades can be considered reliable and provide useful insights into subgeneric relationships. Subgenus *Zeugodacus* as currently recognised is evidently polyphyletic and its retention 'as is' would necessitate the assimilation of all the subgenera recognised in Subgroup (2) of Hancock and

Drew (2018b), resulting in a large and phylogenetically uninformative subgenus of 169 described species. Molecular studies, especially that of San Jose *et al*. (2018), indicate the presence of three distinct clades within the current subgenus *Zeugodacus* s.l. Whereas only one of these clades is identifiable morphologically, none is falsified by morphology and all are supported by biology (host plant use). Division of *Zeugodacus* s.l. into the three separate subgenera recognised here enables the retention of the biogeographically informative subgenera *Asiadacus* Perkins and *Sinodacus* Zia in SE Asia and *Austrodacus* Perkins and *Diplodacus* May in the Australian Region.

While it is possible that the type-species of *Javadacus*, *B*. (*J*.) *montana* (Hardy), might be a flower infester and thus belong in typical *Zeugodacus* s.s., thereby necessitating the proposal of a further new subgenus to accommodate the fruit infesters, there is no evidence to warrant such action at the present time. It is also possible that some other species might be subgenerically misplaced in the lists below: those without host plant or molecular evidence have been placed in either subgenus *Zeugodacus* s.s. or *Javadacus* based on morphological comparison with those that have. This has proved especially difficult with the morphologically similar *scutellaris* and *arisanica* complexes, with subgeneric changes made only where the morphological evidence is considered to be sufficient. This process also resulted in the transfer of *B. quasiinfesta* Drew & Romig from subgenus *Zeugodacus* to subgenus *Sinodacus*. The three recognised subgenera are reviewed below, with species that have their host plants known marked with an asterisk in the lists of included species. For a previous review of *Javadacus* and of other *Zeugodacus* group subgenera see Hancock and Drew (2016, 2017a, b, c, 2018b). A key to the 13 recognised subgenera now included in the *Zeugodacus* group is provided below.

Key to *Zeugodacus* group subgenera

1 Scutum without a postsutural medial yellow vitta; scutellum mostly or entirely yellow, not almost or entirely black 2

– Scutum with a postsutural medial yellow vitta; if vestigial or absent [*B*. (*Z*.) *armillata* (Hering)] then scutellum almost or entirely black 7

2 Postpronotal seta present [Papua New Guinea] ..... *Heminotodacus* Drew

– Postpronotal seta absent 3

3 Male tergite III without a pecten 4

– Male tergite III with a pecten 5

4 Lateral postsutural yellow vittae extending anterior to transverse suture as small spots; prescutellar acrostichal and basal scutellar setae absent; wings without a transverse fuscous band; abdomen fulvous with broad black bands [southern Philippines] ..... *Nesodacus* Perkins

– Lateral postsutural yellow vittae not extending anterior to transverse suture; prescutellar acrostichal and basal scutellar setae present; wings with a transverse fuscous band over either BM-Cu or R-M+DM-Cu crossveins; abdomen fuscous to black without broad bands [northern Maluku and New Guinea] ..... *Perkinsidacus* Hancock & Drew

5 Lateral postsutural yellow vittae and yellow presutural triangles absent; postpronotal lobes yellow; wing with a broad, transverse dark fuscous band over R-M and DM-Cu crossveins bordering a large, pale fuscous apical area; abdomen dark reddish brown without black transverse bands or medial vitta [Madagascar] ..... *Aglaodacus* Munro

– Lateral postsutural yellow vittae and yellow presutural triangles not both absent; if so then postpronotal lobes fuscous or orange-brown, wing not as above and abdomen entirely pale 6

6 Basal scutellar setae absent; if present then prescutellar acrostichal setae also present, presutural yellow spots small and not joined to notopleural lobes, scutellum without a broad basal or subapical black band, abdominal tergites III-V entirely black and female oviscape short [India to New Caledonia; the Indian *B. duplicata* (Bezzi) is included provisionally] ..... *Parasinodacus* Drew & Romig

– Basal scutellar setae present; prescutellar acrostichal setae present or absent; lateral postsutural yellow vittae present and extending anteriorly as small presutural spots, if absent then a large presutural triangle is present and joined to the notopleural lobe and scutellum with a black subapical patch; abdomen mostly fulvous to orange-brown, if tergites III-V entirely fuscous then scutellum with a semicircular black basal area; female oviscape (where known) very long and tubular [Philippines? and Sabah to western New Guinea] ..... *Paradacus* Perkins

7 Lateral postsutural yellow vittae and yellow presutural triangles both present, the latter joined to yellow notopleural lobes; wing without dark areas apart from costal band and anal stripe, the costal band not expanded into a broad apical patch reaching vein M; femora entirely fulvous; scutum extensively black at least between medial and lateral postsutural yellow vittae but not entirely black between postpronotal lobes; often with medial yellow vitta extending anterior to presutural triangles and abdomen with fuscous lateral area on tergite IV separated into a sublateral stripe and narrow lateral margin or an isolated sublateral stripe, if not then lateral postsutural vittae very long and narrow, broadening posteriorly and extending well beyond the intra-alar setae and fuscous lateral area on tergite IV either ring-shaped or broad and posteriorly indented [Sri Lanka and India to Philippines and Sulawesi] ..... *Capparidacus* **subgen. n.**

– Not with the above combination of characters 8

8 Male without pecten on abdominal tergite III; lateral postsutural yellow vittae present; wing with a very narrow costal band of uniform width in cells r_{2+3} and r_{4+5}; abdomen pale, without a black M-shaped pattern on tergite III [New Guinea and Australia] ..... *Austrodacus* Perkins

– Male with pecten on abdominal tergite III; if absent then lateral postsutural yellow vittae absent or wing with costal band distinctly broader apically than subapically and abdominal tergites III-V almost or entirely black or with a black M-shaped pattern (anteriorly, medially and laterally) on tergite III 9

9 Supra-alar and prescutellar acrostichal setae both absent; wing hyaline except for a very narrow costal band of uniform width in cells r_{2+3} and r_{4+5} and an anal stripe; scutum and abdomen fulvous with at most a black posteromedial spot on tergite V [Australia] ..... *Diplodacus* May

– Not with the above combination of characters 10

10 Abdominal tergite I [basal part of fused syntergite I+II] quadrate, about as broad as long; wing with either a large, rounded apical infuscation that crosses vein M and more than half width of cell m or with a broad costal band that crosses vein R_{4+5} at least over basal half of cell r_{4+5} but does not cross vein M; if wing with the latter pattern then lateral presutural yellow bands present joining the postpronotal and notopleural lobes; prescutellar acrostichal setae absent [India to Sulawesi; includes groups A and B of Hancock and Drew (2018b) plus *B.* (*S.*) *quasiinfesta* Drew & Romig, 2013, transferred here from subgenus *Zeugodacus*] ..... *Sinodacus* Zia

– Abdomen with tergite I normally distinctly broader than long, if not then other characters not as above 11

11 Lateral postsutural yellow vittae and yellow presutural triangles both present, the latter joined to yellow notopleural lobes; wing with the costal band expanded into an isolated or weakly joined, broad but not rounded apical infuscation reaching vein M but extending less than half width of cell m; femora entirely fulvous; supra-alar, prescutellar acrostichal and basal scutellar setae all absent [Thailand to Sulawesi and Mindanao] ……..... *Asiadacus* Perkins

– Not with the above combination of characters 12

12 Reared from flowers [primarily male buds] of Cucurbitaceae; placed in Clade C of San Jose *et al.* (2018) [Sri Lanka to Japan, Australia and Vanuatu] ……..... *Zeugodacus* Hendel

– Reared from fruit of Cucurbitaceae, Celastraceae, Euphorbiaceae or Loganiaceae, occasionally other families and rarely both fruit and flowers of Cucurbitaceae; placed in Clade D of San Jose *et al.* (2018) [Sri Lanka to Japan, Australia and Solomon Islands] ……... *Javadacus* Hardy

[These two subgenera are separated reliably only by host plant and/or molecular data].

Genus *Bactrocera* Macquart
Subgenus *Capparidacus* subgen. n.

Type species *Dacus gavisus* Munro, 1935, by present designation.

Definition. Male abdominal sternite V with a slight posterior emargination; posterior lobe of male surstylus long; pecten of cilia on abdominal tergite III of male present; postpronotal setae absent; supra-alar setae present or absent; prescutellar acrostichal setae present; 2 pairs of scutellar setae; scutum with medial and lateral postsutural yellow vittae and presutural yellow triangles united with the notopleural lobes; abdomen with tergite I not quadrate.

Response to male lures. Cue lure (all species – Drew and Romig 2013).

Host plants. Fruit of Capparaceae or unknown.

Included species. *Bactrocera* (*C.*) *fereuncinata* Drew & Romig, *B*. (*C.*) *gavisa* (Munro)*, *B*. (*C.*) *isolata* (Hardy)*, *B*. (*C.*) *juxtuncinata* Drew & Romig, *B*. (*C.*) *ujungpandangiae* Drew & Romig, *B*. (*C.*) *uncinata* Drew & Romig.

Comments. The shape of the male sternite V and long posterior surstylus lobe place this subgenus in the *Zeugodacus* group, with molecular evidence (San Jose *et al*. 2018, C. Doorenweerd pers. comm.) indicating a monophyletic group that splits off before their Clades C and D and includes *B. isolata*, *B. juxtuncinata*, *B. fereuncinata* [= ms1464 *Z.* sp-102] and *B. uncinata*. Host plant and/or morphological similarities enable the inclusion of *B. gavisa* and *B*. *ujungpandangiae.* In addition to the defining characters noted above, wing without dark markings except for narrow costal band and anal stripe, legs with all femora fulvous and abdomen with black sublateral area on tergite IV partly or entirely separated from black lateral margin, if not then scutum with lateral postsutural vittae long, narrow and extending beyond intra-alar setae.

B. (*Capparidacus*) *fereuncinata* Drew & Romig

Bactrocera (*Papuodacus*) *fereuncinata* Drew & Romig, 2013: 216.

Bactrocera (*Zeugodacus*) *fereuncinata* Drew & Romig: Hancock and Drew 2018b: 188.

Distribution. Thailand and Laos (C. Doorenweerd pers. comm.).

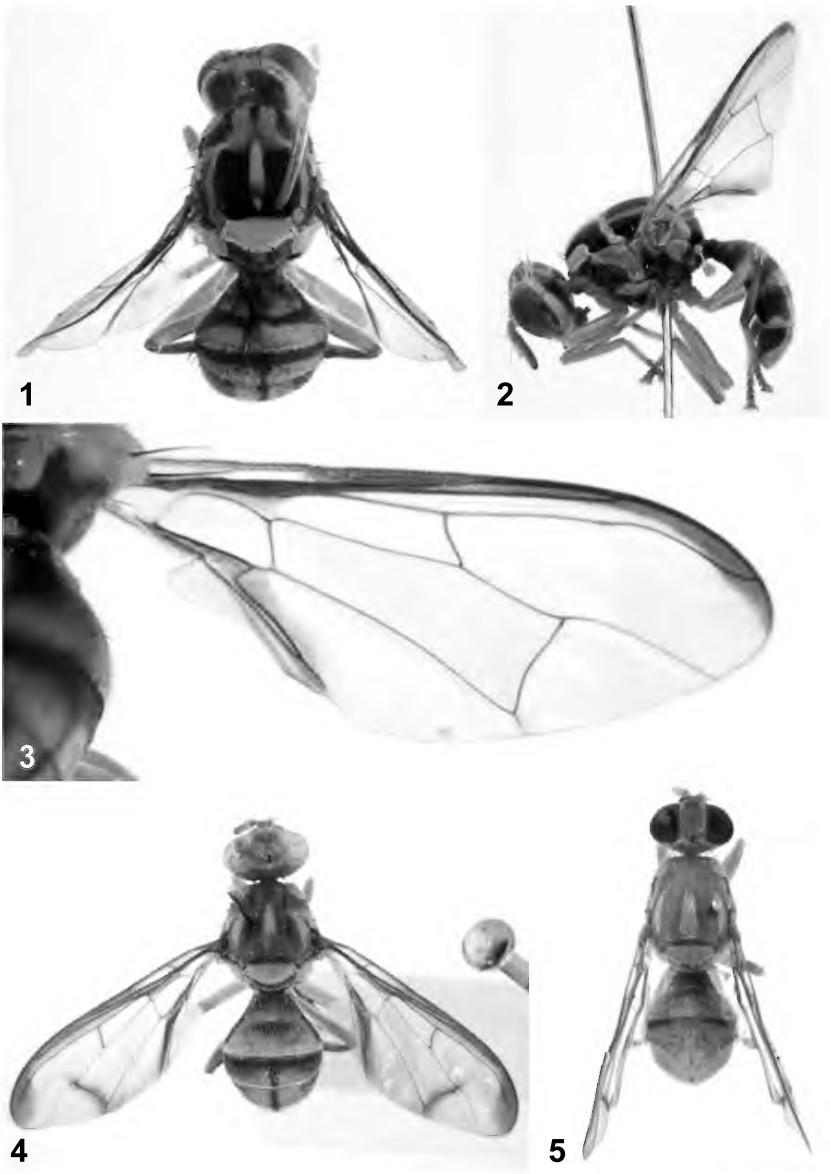
Host plants. Unknown.

Comments. The loss of the supra-alar setae is a homoplasious condition seen frequently within *Bactrocera*. The large, circular facial spots help distinguish it from the other species in the subgenus.

B. (*Capparidacus*) *gavisa* (Munro) (Figs 1-3)

Dacus gavisus Munro, 1935: 15. Type locality Barkuda Island, Chika Lake, Ganjam district, Orissa, India.

Bactrocera (*Zeugodacus*) *gavisa* (Munro): Norrbom *et al*. 1999: 102; Drew and Romig 2013: 296.



Figs 1-5. *Bactrocera* spp: (1-3) *B.* (*Capparidacus*) *gavisa* (Munro) male from Coonoor, India: (1) dorsal view, (2), lateral view, (3) wing; (4) *B*. (*Javadacus*) *chorista* (May) paratype male from Atherton, Qld; (5) *B*. (*Zeugodacus*) *strigifinis* (Walker) male from Cairns, Qld. Photos by Justin Bartlett (Qld Dept of Agriculture & Fisheries, Brisbane).

Distribution. India and Sri Lanka.

Host plant. Capparis roxburghii (Tsuruta *et al*. 1997).

Comments. The broad anepisternal yellow stripe, reaching the postpronotal lobe dorsally, together with the very long and narrow postsutural lateral yellow vittae and the at most weakly posteriorly indented fuscous lateral area on tergite IV, readily distinguish this species.

B. (*Capparidacus*) *isolata* (Hardy)

Dacus (*Zeugodacus*) *isolatus* Hardy, 1973: 61. Type locality Nan, Thailand.

Bactrocera (*Zeugodacus*) *isolata* (Hardy): Norrbom *et al*. 1999: 103; Drew and Romig 2013: 307.

Distribution. Thailand, Laos and Vietnam.

Host plants. Capparis grandis, C. microcantha, C. pyrifolia, C. sepiaria, C. siamensis, C. thorellii, Maerua siamensis (Allwood *et al*. 1999).

Comments. This species is easily separated from other members of the subgenus by the very long and narrow postsutural lateral yellow vittae and ring-like fuscous lateral area on tergite IV. It further differs from *B. gavisa* in the narrow anepisternal yellow stripe.

B. (*Capparidacus*) *juxtuncinata* Drew & Romig

Bactrocera (*Zeugodacus*) *juxtuncinata* Drew & Romig, 2013: 309. Type locality Polomolok, S. Cotabato, Mindanao, Philippines.

Distribution. Philippines (Mindanao).

Host plants. Unknown.

Comments. The almost completely divided fuscous lateral area on tergite IV and long, parallel-sided postsutural lateral yellow vittae most resemble those of *B. fereuncinata*, from which it differs in the elongate-oval facial spots and presence of supra-alar setae.

B. (*Capparidacus*) *ujungpandangiae* Drew & Romig

Bactrocera (*Zeugodacus*) *ujungpandangiae* Drew & Romig, 2013: 363. Type locality Bengo Forest nr Ujung Pandang, Sulawesi.

Distribution. Indonesia (Sulawesi).

Host plants. Unknown.

Comments. This species is distinguished by the reduced abdominal markings, represented by a narrow medial vitta and isolated areas on tergites III and IV, the lateral margins fulvous. The facial spots are medium-sized and circular.

B. (*Capparidacus*) *uncinata* Drew & Romig

Bactrocera (*Zeugodacus*) *uncinata* Drew & Romig, 2013: 364. Type locality Mt Makiling, Luzon, Philippines.

Distribution. Philippines (Luzon).

Host plants. Unknown.

Comments. This species most resembles *B. juxtuncinata*, from which it differs in the short and triangular postsutural lateral yellow vittae.

Key to *Capparidacus* species

1 Scutum with postsutural lateral yellow vittae narrow and elongate, broadening posteriorly and extending beyond intra-alar setae; postsutural medial yellow vitta not extending anteriorly beyond level of yellow presutural triangle; anepisternal yellow band reaching at least level of anterior notopleural seta; abdominal tergite IV with black sublateral patch extending along anterior margin to unite with black lateral margin 2

– Scutum with postsutural lateral yellow vittae broad and not extending beyond intra-alar setae; postsutural medial yellow vitta extending anteriorly beyond level of yellow presutural triangle; anepisternal yellow band not reaching level of anterior notopleural seta; abdominal tergite IV with black sublateral patch not extending along anterior margin anteriorly to unite with black lateral margin 3

2 Anepisternal yellow stripe reaching postpronotal lobe; postsutural medial yellow vitta spindle-shaped; wing with costal band uniformly narrow, not broadly expanded at apex; abdomen with black lateral area on tergite IV not enclosing a large, fulvous central area ..... *B.* (*C.*) *gavisa* (Munro)

– Anepisternal yellow stripe not reaching postpronotal lobe; postsutural medial yellow vitta not spindle-shaped, broadened posteriorly; wing with costal band broadly expanded at apex; abdomen with black lateral area on tergite IV enclosing a large, fulvous central area ... *B.* (*C.*) *isolata* (Hardy)

3 Postsutural lateral yellow vittae not reaching intra-alar setae and sharply narrowed posteriorly ..... *B.* (*C.*) *uncinata* Drew & Romig

– Postsutural lateral yellow vittae reaching intra-alar setae and parallel-sided 4

4 Abdomen with black markings reduced to a narrow medial vitta on tergites III-V and isolated patches on tergites III and IV .... *B.* (*C.*) *ujungpandangiae* Drew & Romig

– Abdomen with a black T-shaped marking anteriorly on tergite III and medially on tergites III-V , plus a black sublateral patch on tergite IV that unites with the black lateral margin on tergites III-V 5

5 Supra-alar setae absent; facial spots circular .... *B.* (*C.*) *fereuncinata* Drew & Romig

– Supra-alar setae present; facial spots elongate-oval .... *B.* (*C.*) *juxtuncinata* Drew & Romig

Subgenus *Javadacus* Hardy

Dacus (*Javadacus*) Hardy, 1983: 26. Type species *Dacus* (*Javadacus*) *montanus* Hardy, 1983, by original designation.

Definition. Male abdominal sternite V with a slight posterior emargination; posterior lobe of male surstylus long; pecten of cilia on abdominal tergite III of male present (except in *B. mukiae*); postpronotal setae absent (except weakly present in *B. hatyaiensis*); supra-alar setae present or absent; prescutellar acrostichal setae present or absent; 1 or 2 pairs of scutellar setae; scutum with medial and lateral postsutural yellow vittae and either presutural extensions or (*B. connexa* and *B. flavolateralis*) narrow presutural lateral yellow vittae, the presutural extensions triangular and united with the notopleural lobes in 4 species (weakly in *B. cucurbitae*); abdomen with tergite I not quadrate.

Response to male lures. Cue lure (48 spp), methyl eugenol [contaminated traps or lure?] (*B. iriomotiae*) or unknown (36 spp) (Drew 1989, Drew and Romig 2001, 2013, 2016). *Bactrocera cucurbitae* also shows a weak response to zingerone (Royer *et al*. 2018).

Host plants. Fruit of Cucurbitaceae or (five *maculifacies* complex species) fruit of Celastraceae, Euphorbiaceae or Loganiaceae. Occasionally, fruit of other families and Cucurbitaceae flowers are used by polyphagous species such as *B. cucurbitae* and *B. tau*.

Included species. The 85 described species are placed in 10 complexes:

arisanica complex [India and Sri Lanka to Taiwan]: *B*. (*J*.) *aithonota* Drew & Romig, *B*. (*J*.) *arisanica* (Shiraki), *B*. (*J*.) *liquida* Drew & Romig, *B*. (*J*.) *mukiae* Drew & Romig*, *B*. (*J*.) *nigrifacies* (Shiraki), *B*. (*J*.) *scutellaria* (Bezzi), *B*. (*J*.) *sonlaiae* Drew & Romig, *B*. (*J*.) *tappanus* (Shiraki), *B*. (*J*.) *trilineata* (Hardy)*.

cucurbitae complex [widespread from Arabia to Solomon Is; adventive in Hawaii, Africa, Seychelles and Mascarenes]: *B*. (*J*.) *cucurbitae* (Coquillett)*.

decipiens complex [New Guinea and New Britain]: *B*. (*J*.) *decipiens* (Drew)*, *B*. (*J*.) *mesonotaitha* Drew, *B*. (*J*.) *sandaracina* Drew.

depressa complex [Thailand to China, Japan, Taiwan, Philippines, Malaysia and Borneo]: *B*. (*J*.) *bezziana* (Hering)*, *B*. (*J*.) *depressa* (Shiraki)*, *B*. (*J*.) *indentus* (Hardy), *B*. (*J*.) *macrophyllae* Drew & Romig*, *B*. (*J*.) *pubescens* (Bezzi), *B*. (*J*.) *rubella* (Hardy)*, *B*. (*J*.) *trichosanthes* Drew & Romig*, *B*. (*J*.) *tricuspidatae* Drew & Romig*, *B*. (*J*.) *trimaculata* (Hardy & Adachi)*.

maculata complex [Bhutan and China to Peninsular Malaysia and Borneo]: *B*. (*J*.) *hatyaiensis* Drew & Romig, *B*. (*J*.) *maculata* (Perkins), *B*. (*J*.) *ochrosterna* Drew & Romig, *B*. (*J*.) *platamus* (Hardy), *B*. (*J*.) *proprescutellata* Zhang, Chen & Gao, *B*. (*J*.) *sinensis* Yu, Bai & Chen.

maculifacies complex [Thailand to Japan, Taiwan and Sulawesi]: *B*. (*J*.) *ambigua* (Shiraki), *B*. (*J*.) *connexa* (Hardy), *B*. (*J*.) *flavolateralis* Drew & Romig*, *B*. (*J*.) *flavoverticalis* Drew & Romig*, *B*. (*J*.) *hengsawadae* Drew & Romig*, *B*. (*J*.) *iriomotiae* Drew & Romig, *B*. (*J*.) *maculifacies* (Hardy)*, *B*. (*J*.) *yalaensis* Drew & Romig*.

munda complex [Philippines and Peninsular Malaysia to Sumatra. Java, Borneo and Sulawesi]: *B*. (*J*.) *apicofemoralis* Drew & Romig, *B*. (*J*.) *bogorensis* (Hardy), *B*. (*J*.) *calumniata* (Hardy), *B*. (*J*.) *careomacula* Drew & Romig, *B*. (*J*.) *diaphoropsis* (Hering), *B*. (*J*.) *flavopectoralis* Drew & Romig, *B*. (*J*.) *hululangatiae* Drew & Romig, *B*. (*J*.) *javanensis* (Perkins), *B*. (*J*.) *melanopsis* (Hardy), *B*. (*J*.) *montana* (Hardy), *B*. (*J*.) *munda* (Bezzi)*, *B*. (*J*.) *neoelegantula* White.

synnephes complex [Sulawesi and Bali to Solomon Islands and NE Australia except *B. synnephes* also widespread in SE Asia]: *B*. (*J*.) *abdoangusta* (Drew), *B*. (*J*.) *anchitrichota* Drew, *B*. (*J*.) *baliensis* Drew & Romig, *B*. (*J*.) *borongensis* Drew & Romig, *B*. (*J*.) *buruensis* White, *B*. (*J*.) *chorista* (May)* (Fig. 4), *B*. (*J*.) *complicata* White, *B*. (*J*.) *curta* (Drew), *B*. (*J*.) *dubiosa* (Hardy), *B*. (*J*.) *emittens* (Walker), *B*. (*J*.) *flavipilosa* (Hardy), *B*. (*J*.) *fulvoabdominalis* White & Evenhuis, *B*. (*J*.) *fuscipennula* Drew & Romig, *B*. (*J*.) *hamaceki* Drew & Romig, *B*. (*J*.) *neoemittens* Drew & Romig, *B*. (*J*.) *neoflavipilosa* Drew & Romig, *B*. (*J*.) *perplexa* (Walker), *B*. (*J*.) *persignata* (Hering), *B*. (*J*.) *semisurstyli* Drew & Romig, *B*. (*J*.) *sumbensis* (Hering), *B*. (*J*.) *synnephes* (Hendel), *B*. (*J*.) *trichota* (May), *B*. (*J*.) *vargus* (Hardy).

tau complex [Pakistan, India and Sri Lanka to Taiwan, Philippines and Sulawesi]: *B*. (*J*.) *havelockiae* Drew & Romig*, *B*. (*J*.) *heinrichi* (Hering), *B*. (*J*.) *hodgsoniae* Drew & Romig*, *B*. (*J*.) *javadica* Mahmood, *B*. (*J*.) *khaoyaiae* Drew & Romig, *B*. (*J*.) *okunii* (Shiraki), *B*. (*J*.) *signata* (Hering), *B*. (*J*.) *tapervitta* Mahmood*, *B*. (*J*.) *tau* (Walker)*, *B*. (*J*.) *tebeduiae* Drew & Romig, *B*. (*J*.) *trivandrumensis* Drew & Romig, *B*. (*J*.) *zahadi* Mahmood*.

watersi complex [India and Andaman Islands]: *B*. (*J*.) *fuscoalata* Drew & Romig, *B*. (*J*.) *watersi* (Hardy)*.

Comments. This is the most speciose of the *Zeugodacus* group subgenera, separated from *Zeugodacus* s.s. only by molecular and host plant evidence. It belongs in Clade D of San Jose *et al*. (2018) and recorded host plants are primarily fruit of Cucurbitaceae, although five *maculifacies* complex species have been recorded only from other families: *B*. (*J*.) *maculifacies* and *B*. (*J*.) *hengsawadae* from Celastraceae (*Siphonodon*), *B*. (*J*.) *flavolateralis* from Euphorbiaceae (*Drypetes*) and *B*. (*J*.) *flavoverticalis* and *B*. (*J*.) *yalaensis* from Loganiaceae (*Strychnos* and *Fagraea* respectively). It is possible that all species in the *maculifacies* complex utilise non-cucurbitaceaous fruits. Of its 85 included species, 80 are transferred from subgenus *Zeugodacus*, including the pest species *B*. (*J*.) *cucurbitae*, *B*. (*J*.) *depressa* and *B*. (*J*.) *tau*.

The aculeus is apically needle-like or trilobed, the latter having the medial lobe much more distinctly produced than in the weakly trilobed subgenus *Austrodacus*. The *decipiens* complex has distinct subapical keels (see figs 352, 363A and 399A in Drew 1989) and is separated from other *B.* (*Javadacus*) species with a trilobed aculeus by lacking the dark T-shaped marking on abdominal tergites III-V. Similarly, the *depressa* complex has an apically trilobed aculeus while the very similar *tau* complex has a needle-like aculeus. Interestingly, none of the species in the *decipiens*, *depressa* and *watersi* complexes, all of which have a trilobed aculeus, responds [more than at most incidentally] to known male lures.

Polyphagous species such as *B. cucurbitae* and *B. tau* are known from a wide range of host plant families and also, occasionally, from cucurbit flowers (Allwood *et al.* 1999, Drew and Romig 2013) but note that records of *B. tau* from *Fagraea* (Loganiaceae) actually refer to *B. yalaensis*, while *B. zahadi* (a probable synonym of *B. tau* – see Drew and Romig 2013) also uses *Adenia* (Passifloraceae) (Tsuruta *et al.* 1997, as *B.* (*Z.*) sp. near *tau* Taxon C) and *B. depressa* occasionally infests tomatoes (Solanaceae) (Han *et al*. 2017). *Bactrocera bezziana* has been bred from *Cucumis* fruit (Cucurbitaceae) in Gansu Province, China (Liang *et al.* 1993, as *B.* (*Z.*) sp. near *tau*).

Bactrocera bezziana, placed as a synonym of *B. depressa* by Han *et al.* (2017) and *B. hengsawadae*, placed as a synonym of *B. maculifacies* by Hancock and Drew (2018b), differ in slight but constant morphological details (width of lateral yellow vittae or size of supernumerary lobe) and are treated here as distinct. For species previously transferred to subgenus *Bactrocera* see Hancock and Drew (2017a).

Subgenus *Zeugodacus* Hendel

Dacus (*Zeugodacus*) Hendel, 1927: 26. Type species *Dacus caudatus* Fabricius, 1805, by original designation.

Dacus (*Pacifodacus*) Drew, 1972: 12. Type species *Asiadacus triangularis* Drew, 1968, by original designation. **Syn. n.**

Dacus (*Papuodacus*) Drew, 1972: 13. Type species *Dacus pallescentis* Drew, 1971 (= *Bactrocera neopallescentis* Drew, 1989), by original designation. **Syn. n.**

Dacus (*Hemigymnodacus*) Hardy, 1973: 19. Type species *Dacus diversus* Coquillett, 1904, by original designation. Syn. Hancock and Drew 2018b: 186.

Bactrocera (*Niuginidacus*) Drew, 1989: 15. Type species *Bactrocera singularis* Drew, 1989, by original designation. **Syn. n.**

Definition. Male abdominal sternite V with a slight posterior emargination; posterior lobe of male surstylus long; pecten of cilia on abdominal tergite III of male present (except in *B. diversa* and *B. singularis*); postpronotal setae absent; supra-alar setae present or absent; prescutellar acrostichal setae present or absent; 1 or 2 pairs of scutellar setae; scutum with medial and lateral postsutural yellow vittae and often [41 of 60 spp] with presutural

extensions [united with postpronotal lobes in 4 spp]; presutural lateral yellow vittae often present in the *strigifinis* complex [9 of 23 spp]; abdomen with tergite I not quadrate except in some *strigifinis* complex species.

Response to male lures. Cue lure (49 spp), methyl eugenol [weakly] (*B. diversa*) or unknown (10 spp). (Drew 1989, Drew and Romig 2001, 2013, 2016, Zhou *et al*. 2013). *Bactrocera triangularis* also shows a weak response to zingerone (Royer *et al*. 2018).

Host plants. Flowers [primarily male buds] of Cucurbitaceae.

Included species. The 60 described species are placed in three complexes:

scutellaris complex [Pakistan, India and Sri Lanka to Japan, Timor and Damar]: *B.* (*Z.*) *anala* Chen & Zhou, *B*. (*Z.*) *apiciflava* Yu, He & Chen, *B*. (*Z.*) *armillata* (Hering), *B*. (*Z.*) *assamensis* White, *B*. (*Z.*) *atrifacies* (Perkins), *B*. (*Z.*) *baoshanensis* Zhang, Ji, Yang & Chen, *B*. (*Z.*) *biguttata* (Bezzi), *B*. (*Z.*) *caudata* (Fabricius)*, *B*. (*Z.*) *daclaciae* Drew & Romig, *B*. (*Z.*) *diaphora* (Hendel), *B*. (*Z.*) *diversa* (Coquillett)*, *B.* (*Z.*) *dorsirufa* Drew & Romig, *B*. (*Z.*) *exornata* (Hering), *B*. (*Z.*) *freidbergi* White, *B*. (*Z.*) *hekouana* Yu, He & Yang, *B*. (*Z.*) *hoabinhiae* Drew & Romig, *B*. (*Z.*) *ishigakiensis* (Shiraki), *B*. (*Z.*) *kaghanae* Mahmood, *B*. (*Z.*) *laguniensis* Drew & Romig, *B*. (*Z.*) *lipsana* (Hendel), *B*. (*Z.*) *maculifemur* (Hering), *B*. (*Z.*) *melanofacies* Drew & Romig, *B*. (*Z.*) *menglana* Yu, Liu & Yang, *B*. (*Z.*) *nakhonnayokiae* Drew & Romig, *B*. (*Z.*) *namlingiae* Drew & Romig, *B*. (*Z.*) *neolipsana* Drew & Romig, *B*. (*Z.*) *pemalangiae* Drew & Romig, *B*. (*Z.*) *sabahensis* Drew & Romig, *B*. (*Z.*) *sasaotiae* Drew & Romig, *B*. (*Z.*) *scutellaris* (Bezzi)*, *B*. (*Z.*) *scutellata* (Hendel)*, *B*. (*Z.*) *scutellina* (Bezzi), *B*. (*Z.*) *semongokensis* Drew & Romig, *B*. (*Z.*) *vulta* (Hardy), *B*. (*Z.*) *yoshimotoi* (Hardy).

strigifinis complex [Philippines, Borneo and Sulawesi to Vanuatu and NE Australia]: *B*. (*Z.*) *abnormis* (Hardy), *B*. (*Z.*) *amoena* (Drew), *B*. (*Z.*) *angusticostata* Drew, *B*. (*Z.*) *aurantiventer* Drew, *B*. (*Z.*) *brachus* (Drew), *B*. (*Z.*) *buvittata* Drew, *B.* (*Z.*) *citroides* Drew, *B*. (*Z.*) *daula* Drew, *B*. (*Z.*) *elegantula* (Hardy), *B*. (*Z.*) *emarginata* (Perkins), *B*. (*Z.*) *fallacis* (Drew), *B*. (*Z.*) *gracilis* (Drew), *B.* (*Z.*) *macrovittata* Drew, *B.* (*Z.*) *neopallescentis* Drew, *B*. (*Z.*) *paulula* Drew, *B*. (*Z.*) *reflexa* (Drew), *B*. (*Z.*) *sepikae* Drew, *B.* (*Z.*) *singularis* Drew, *B*. (*Z.*) *strigifinis* (Walker)* (Fig. 5), *B*. (*Z.*) *surrufula* Drew, *B*. (*Z.*) *triangularis* (Drew)*, *B.* (*Z.*) *unilateralis* Drew, *B*. (*Z.*) *univittata* (Drew).

timorensis complex [Flores and Timor]: *B*. (*Z.*) *minima* (Hering), *B*. (*Z.*) *timorensis* (Perkins).

Comments. This is the second most speciose of the *Zeugodacus* group subgenera, with 60 species included: many, particularly in the *scutellaris* complex, are retained here provisionally until host plant or molecular data become available. All 11 species retained by Hancock and Drew (2018b) in

the here newly synonymised subgenera *Papuodacus*, *Niuginidacus* and *Pacifodacus* (= *Sinodacus* Groups C + D) are transferred: all appear to belong in the *strigifinis* complex. *Zeugodacus* s.s. is separated from *Javadacus* only by molecular and host plant evidence, belonging in Clade C of San Jose *et al*. (2018) and recorded only from the flowers of Cucurbitaceae.

Bactrocera (*Z*.) *anala* Chen & Zhou from southern China was not treated by Drew and Romig (2013, 2016). It differs from the very similar *B*. (*Z*.) *biguttata* (Bezzi) (= *adusta* Wang & Zhao) in having basal scutellar setae present and wing with a darker anal stripe and narrower apical spot (Zhou *et al.* 2013). The Nepalese *B. luteicinctuta* Ito is regarded as a synonym of *B.* (*Z*.) *yoshimotoi* (Hardy), while *B. laocaiae* Drew & Romig was placed as a synonym of *B.* (*Z*.) *baoshanensis* by Drew and Romig (2016).

A note on subgenus *Sinodacus* Zia

With the removal of Groups C and D of Hancock and Drew (2018b) to *Zeugodacus* s.s., subgenus *Sinodacus* is restricted to Groups A and B and its definition revised: abdominal sternite V of male with a slight to moderate posterior emargination; posterior lobe of male surstylus long; pecten of cilia on abdominal tergite III of male present; postpronotal setae absent; supra-alar setae present or absent; prescutellar acrostichal setae absent; 1-2 pairs of scutellar setae (basals usually absent); scutum with postsutural medial yellow vitta present; abdomen with tergite I quadrate. Ten species are included, placed in two complexes. For separation of *B. quasiinfesta* see the revised key provided below and for illustrations of all species see Drew and Romig (2013, 2016), David *et al.* (2017) and Hancock and Drew (2018b).

hochii complex (Group A) [India to China, Philippines, Sulawesi and Sumba]: *Bactrocera* (*S*.) *brevipunctata* David & Hancock, *B.* (*S*.) *fuscans* (Wang), *B*. (*S*.) *hochii* (Zia)*, *B*. (*S*.) *infesta* (Enderlein), *B*. (*S*.) *quasiinfesta* Drew & Romig (newly transferred from *Zeugodacus*), *B.* (*S*.) *transversa* (Hardy) and *B*. (*S*.) *whitei* Drew & Romig.

longivittata complex (Group B) [Peninsular Malaysia, Borneo and Philippines]: *Bactrocera* (*S*.) *longivittata* Chua & Ooi, *B*. (*S*.) *speciosa* Drew & Romig, *B*. (*S*.) *spectabilis* Drew & Romig.

Revised key to *Sinodacus* species

1 Wing with costal band expanded at apex into a large spot crossing vein M into cell m; scutum without a presutural lateral yellow vitta connecting postpronotal and notopleural lobes (*hochii* complex) 2

– Wing with costal band broad but not expanded at apex into a large spot crossing vein M into cell m; scutum with a presutural lateral yellow vitta connecting postpronotal and notopleural lobes (*longivittata* complex) 8

2 Scutum red-brown with at most small or narrow black markings 3

– Scutum mostly black 6

3 Face with a pair of isolated or narrowly joined black spots; scutum with lateral postsutural vittae long, parallel-sided and ending behind intra-alar setae …….. 4

– Face with a transverse black band; scutum with lateral postsutural vittae absent or vestigial and ending well before intra-alar setae 5

4 Femora mostly black over apical two-thirds; postsutural medial yellow vitta small, not reaching level of postalar setae posteriorly; wing with anal stripe narrow and fulvous [Thailand and Vietnam to Sumatra and Java] ..... *B*. (*S*.) *infesta* (Enderlein)

– Fore femur with a dark streak, mid and hind femora fulvous; postsutural medial yellow vitta large, reaching beyond level of postalar setae posteriorly; wing with anal stripe broad and fuscous [Thailand] ……..... ..... *B*. (*S*.) *quasiinfesta* Drew & Romig

5 Scutum with yellow triangle along transverse suture joined to notopleural lobe; femora entirely fulvous to red-brown [SE Asia] .. *B*. (*S*.) *hochii* (Zia)

– Scutum with yellow spot along transverse suture separated from notopleural lobe; femora with apical third fuscous to black [SW India] ..... *B*. (*S*.) *brevipunctata* David & Hancock

6 Face mostly black; scutum with medial postsutural vitta narrow and elongate and lateral postsutural yellow vittae elongate, parallel-sided and extending almost to intra-alar setae; wing with costal band not or only faintly crossing vein R_{2+3} and not broadly united with the large apical spot [southern China] ..... *B*. (*S*.) *fuscans* (Wang)

– Face with a pair of black spots and sometimes a band across oral margin; scutum with medial postsutural vitta broadly triangular or reduced to a narrow transverse bar and lateral postsutural yellow vittae short, triangular and at most slightly extending beyond line of supra-alar setae; wing with costal band crossing vein R_{2+3} to vein R_{4+5} and broadly united with the large apical spot 7

7 Scutum with medial postsutural vitta reduced to a narrow and transverse prescutellar bar and yellow triangle along suture joined to notopleural lobe; postpronotal lobes fuscous [Sulawesi]. .... *B*. (*S*.) *transversa* (Hardy)

– Scutum with medial postsutural vitta broadly triangular and yellow triangle along suture separated from notopleural lobe; postpronotal lobes yellow [Philippines and Sabah] ..... *B*. (*S*.) *whitei* Drew & Romig

8 Femora red-brown; face fulvous with a pair of black spots; abdomen with fuscous lateral markings on tergites IV and V small and restricted to anterolateral corners [West Malaysia] ..... *B*. (*S*.) *longivittata* Chua & Ooi

– Femora largely fuscous to black, especially hind pair; face mostly fuscous to black with or without a pair of black spots; abdomen with fuscous lateral markings on tergite IV broad and united with that on tergite V … 9

9 Wing with costal band broadly and uniformly crossing vein R_{4+5} into cells br and r_{4+5}; scutum red-brown with longitudinal black submedial and dorsocentral vittae, prescutellar margin and presutural patches [Philippines: Luzon] ..... *B*. (*S*.) *spectabilis* Drew & Romig

– Wing with costal band at most weakly crossing vein R_{4+5} into cell br and basal half of cell r_{4+5} before expanding into apical half of cell r_{4+5}; scutum entirely black except for yellow markings [East Malaysia: Sabah] .... *B*. (*S*.) *speciosa* Drew & Romig

Discussion

Molecular evidence

Recent molecular studies have been consistent in the recognition of the two well supported and distinct clades represented in this study by subgenera *Zeugodacus* s.s. and *Javadacus* (*e.g*. Zhang *et al*. 2010, Krosch *et al*. 2012, Virgilio *et al*. 2015, Leblanc *et al*. 2015, Jiang *et al*. 2016, San Jose *et al*. 2018, Song *et al*. 2018, Dupuis *et al*. 2018). San Jose *et al.* (2018) also demonstrated the separate and plesiomorphic status of the new subgenus *Capparidacus*. Those of the above studies that examined species of subgenus *Parasinodacus* Drew & Romig also recognised them as a separate and plesiomorphic group. These molecularly recognised clades are not falsified by morphology, biology or other molecular evidence and, apart from the occasional anomaly, misidentification or likely misplacement, should be considered reliable until or unless demonstrated otherwise. Thus, even though two of the three subgenera recognised here cannot be separated morphologically, the molecular evidence, supported by biological data, enables their recognition and diagnosis. This integrative approach will hopefully lead to a classification that is more stable and informative than those provided by just morphology or molecular evidence alone. Inclusion of the plesiomorphic Dacini genera *Monacrostichus* Bezzi and *Ichneumonopsis* Hardy in molecular studies would be desirable.

Biological evidence

Host plant data support the recognition of the three subgenera adopted here. *Capparidacus* is known only from Capparaceae and *Zeugodacus* only from Cucurbitaceae flowers (primarily male buds), with occasional records of *B. scutellata* also from cecidomyiid galls on cucurbit stems (Han *et al*. 2017). *Javadacus* is known primarily from fruit of Cucurbitaceae, with a few species recorded only from fruit of Celastraceae, Loganiaceae or Euphorbiaceae. With the exception of *B. cucurbitae* from *Phaseolus* and *Vigna* (Fabaceae) and *B. zahadi* from *Adenia* (Passifloraceae), non-cucurbitaceous records, plus those of *B.* (*Z.*) *scutellata* from fruit (see Han *et al*. 2017), are minor or

unusual and at least some are likely to be either secondary infestations of fruit already infested by other species or sampling errors. Records of single specimens of *B. trilineata* from pumpkin flowers (Tsuruta *et al.* 1997) and *B.* (*Parasinodacus*) *cilifer* (Hendel) from male flowers of the medicinal cucurbit *Thladiantha hookeri* (see Hancock and Drew 2017c) are particularly doubtful and require confirmation. In the molecular studies presented so far, especially that of San Jose *et al*. (2018), no species with a known 'normal' host record has been placed in the 'wrong' clade.

Morphological evidence

Morphological evidence clearly associates the species included in *Capparidacus*, in particular the yellow presutural triangle (homoplasy or plesiomorphy) and the pattern of abdominal tergite IV (apomorphy), with its dark lateral area weakly or strongly indented or divided. *Bactrocera gavisa*, which has the least indented tergite IV pattern, is clearly allied to *B. isolata* by the long and narrow postsutural lateral yellow vittae, which broaden posteriorly and extend well beyond the intra-alar setae (apomorphy). There are no morphological characters that can be used to strictly separate *Zeugodacus* and *Javadacu*s, with both subgenera showing a wide range of homoplasious character states. None of these characters falsifies their separation but, as with the *Dacus* Fabricius subgenera *Callantra* Walker and *Didacus* Collart (see Hancock and Drew 2006), host plant usage appears to be a reliable way of separating them from morphologically similar subgenera. There are trends, however – *Zeugodacus* species are often small, possibly due to a limited larval food supply, whereas *Javadacus* species are generally larger and often have more distinctly patterned wings, but neither of these characters is a reliable indicator of subgeneric placement.

Genus or subgenus?

Whereas molecular evidence for the subgenera proposed here is consistent, that is not the case for the systematic placement of *Zeugodacus* in its widest sense (*i.e.* group of subgenera), variously placed as the sister-group to either *Dacus* or *Dacus* + *Bactrocera* s.s. Both relationships are generally not strongly supported statistically, are falsified by morphological and molecular clock evidence and are not supported by biology, with plesiomorphic subgenera in both *Dacus* and the *Zeugodacus* group using host plants other than Cucurbitaceae (Hancock and Drew 2018b), leaving only the *Bactrocera-Zeugodacus* sister relationship as a viable and non-falsified alternative.

Although the *Zeugodacus* group is evidently monophyletic, its current recognition as a genus is based solely on two now falsified assumptions – a sister-group relationship with *Dacus* and shared Cucurbitaceae host plants (see above). No suitable morphological synapomorphy has been found to define the *Zeugodacus* group and subgeneric status (as also retained by Jiang *et al*. 2016 and Han *et al*. 2017) remains the best option. At present, it is definable morphologically solely on plesiomorphic or homoplasious

characters (primarily the long posterior surstylus lobe, also seen in *Ichneumonopsis* and some *Dacus* species); these are suitable for use at the subgeneric level but are not sufficient for generic status. *Dacus* is defined by the synapomorphic fused (or closely approximate) abdominal tergites and *Bactrocera* (including *Zeugodacus*) by the frequent but unstable presence of additional setae not seen elsewhere in Dacini genera, as noted by Hancock and Drew (2018a, b).

Subgeneric relationships

Capparidacus is a distinctive subgenus, its species being placed near the base of the *Zeugodacus* group by San Jose *et al*. (2018), separate from both *Parasinodacus* and their Clades C and D. The flower-infesting subgenera *Asiadacus* and *Zeugodacu*s s.s. both belong in Clade C, while the fruit-infesting subgenera *Sinodacus*, *Austrodacus*, *Diplodacus* and *Javadacus* all belong in Clade D.

Phylogeny of Subgroup (2) subgenera

The 13 subgenera now placed in the *Zeugodacus* group are listed in Table 1 (modified from Hancock and Drew 2018b), together with their numbers of species and biogeographical distributions. The following evolutionary scenario is proposed as a working hypothesis, testable by future studies.

The early evolutionary history of the four groups of subgenera within *Bactrocera* (*Zeugodacus*, *Tetradacus*, *Melanodacus* and *Bactrocera*) was discussed by Hancock and Drew (2018b), with the centre of origin of the two most plesiomorphic groups, *Zeugodacus* and *Tetradacus*, determined as India during its drifting phase. Consequently, the ancestor of the *Zeugodacus* group would be expected to be a plesiomorphic, non-cucurbit-feeding Indian species with a postsutural medial yellow vitta present. The extant *B.* (*C.*) *gavisa* (Figs 1-3) appears to most resemble this putative ancestral species, its largely intact lateral dark area on abdominal tergite IV placing it at the base of subgenus *Capparidacus*, which (with molecular support) appears to be the most plesiomorphic of the subgenera included in Subgroup (2) (those with a medial vitta) and (in having the vitta) possibly represents the ancestor of both Subgroups (1) and (2). An Indian (*i.e.* Gondwanan) origin of the Dacini, first proposed by Drew and Hancock (1999) and supported by Krosch *et al.* (2012), is further strengthened by the apparent close molecular association between it and the Neotropical genus *Anastrepha* Schiner (Song *et al.* 2018), an association supported by their similar scutal patterns.

The unification of India with Asia *ca* 50-40 Mya (Bouilhol *et al.* 2013) would have enabled a switch to the newly available Cucurbitaceae (Schaefer *et al*. 2009) as host plants, thereby facilitating expansion of Subgroup (2) into SE Asia. San Jose *et al*. (2018) questioned the view that dacines are wasp mimics but the flies' habit of wandering about on leaves or fruit while waving their wings in display or ovipositing would make them very susceptible to

predators such as birds. Closely resembling something as potentially dangerous and unpalatable as a wasp would be to their advantage and would have aided their dispersal into new territories and habitats.

Table 1. List of subgenera in the *Zeugodacus* group now recognised, total number of species and number of species recorded from Africa (including Madagascar) and the Indo-Australian biogeographic Zones A-F as detailed by Hancock and Drew (2015): A = Indian subcontinent; B = South-East Asia; C = Wallacea; D = New Guinea-Solomons; E = Australia; F = South Pacific. Modified from Hancock and Drew (2018b).

Subgenus	Total spp	Africa	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F
Subgroup (1)								
Aglaodacus	**1**	1[1]	0	0	0	0	0	0
Heminotodacus	**1**	0	0	0	0	1	0	0
Nesodacus	**1**	0	0	1	0	0	0	0
Paradacus	**6**	0	0	1	5	1	0	0
Parasinodacus	**20**[2]	0	3	9	4	4	0	1
Perkinsidacus	**2**	0	0	0	1	1	0	0
Subgroup (2)								
Asiadacus	**2**	0	0	2	1	0	0	0
Austrodacus	**5**	0	0	0	0	4	1	0
Capparidacus	**6**	0	1	4	1	0	0	0
Diplodacus	**1**	0	0	0	0	0	1	0
Javadacus	**85**	1[3]	11	56	22	10	1	0
Sinodacus	**10**	0	2	8	2	0	0	0
Zeugodacus	**60**	0	16	31	9	19	2	1
TOTAL SPECIES	**200**	**2**	**33**	**112**	**45**	**40**	**5**	**2**

[1]Madagascar; [2]provisionally includes *B. duplicata* (Bezzi) from India; [3]the sole African species (*B. cucurbitae* (Coquillett)) is an adventive introduced from India.

The two cucurbit-feeding clades, the flower-infesting *Zeugodacus* s.s. and the fruit-infesting *Javadacus* lineages, likely separated soon after the group's arrival in SE Asia – both are widespread throughout the Indo-Australian Region. It is suggested that the two lineages are represented ancestrally by subgenera *Asiadacus* and *Sinodacus* respectively. Both are largely confined to SE Asia and both contain species with similar scutal and abdominal patterns to those seen in *Capparidacus*, including the presutural yellow triangles united with the notopleural lobes. The large apical wing infuscation seen in both subgenera is reminiscent of a similar condition in subgenus

Tetradacus Miyake, regarded both molecularly and morphologically as the most plesiomorphic of the non-*Zeugodacus* group subgenera (*e.g.* Hancock and Drew 2018a).

Zeugodacus s.s. and *Javadacus* are suggested to be of Sundaland origin, differentiating after dispersing into that area following its unification with Asia proper. Both subgenera are well represented in Wallacea and the Australian Region. *Austrodacus* and *Diplodacus*, however, appear to represent a Papuan-Australian offshoot from *Javadacus* before the latter subgenus differentiated further. However, it remains possible that *Javadacus* is paraphyletic with regard to *Austrodacus* and *Diplodacus*, although the reversion to a Capparaceae host plant in *Diplodacus* suggests that it reached Australia before the Cucurbitaceae. *Zeugodacus* s.s. appears to have reached the Papuan-Australian Region alongside or after the Cucurbitaceae as the distinctive *strigifinis* complex, with some species reacquiring a quadrate tergite I otherwise typical of *Sinodacus*. *Javadacus* also likely reached the Papuan-Australian Region alongside or after the Cucurbitaceae, as the endemic *decipiens* complex (with a trilobed aculeus) and as an extension of the *synnephes* complex (with a needle-like aculeus).

It is hoped that this series of subgeneric reviews, begun in 2015 and here concluded, will provide a logical framework for a more detailed phylogenetic analysis of genus *Bactrocera*. A whole genus approach involving character matrices, currently hampered by the large number of known species (*ca* 650 described plus many undescribed) and the almost universal homoplasy of the morphological characters, would be an exercise in futility, with computer analyses leading to a multitude of equally parsimonious and unreliable trees.

Analysing small groups of subgenera separately seems a more viable alternative and would enable fine-tuning of the subgeneric limits established so far. A character matrix study of *Bactrocera* as a genus might then be practicable, based on subgenera rather than individual species.

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ADVENTIVE MOTHS (LEPIDOPTERA) ESTABLISHED IN MAINLAND NEW ZEALAND: ADDITIONS AND NEW IDENTIFICATIONS SINCE 2001

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Abstract

All 31 adventive moth species (Lepidoptera) newly established in New Zealand from 2001-2017 or newly identified in that time are discussed. Brief notes on first record in New Zealand, known distribution, biology and diagnostic characters of adults (and for some species larvae) are provided and all species are illustrated with colour photographs. Larval cases of Psychidae are also described and illustrated. The larva of *Pantydia sparsa* Guenée (Erebidae) is described and illustrated for the first time. *Borkhausenia morella* Hudson, 1939 (Oecophoridae), described from New Zealand, is **newly synonymised** with the Australian *Opsitycha squalidella* (Meyrick, 1884). Of the 31 species treated, 19 are known or strongly suspected to originate from Australia, 5 are of European / Palaearctic origin but likely to have come to New Zealand via Australia, where they are present, 4 are European / Palaearctic but not known from Australia, 2 are originally endemic to Norfolk Island and 1 is from North America. The families represented are: Tineidae (5 species), Psychidae (3 species), Glyphipterigidae (1 species), Coleophoridae (1 species), Oecophoridae (4 species), Depressariidae (1 species), Elachistidae (1 species), Cosmopterigidae (1 species), Blastobasidae (1 species), Gelechiidae (2 species), Tortricidae (1 species), Pyralidae (4 species), Crambidae (2 species), Geometridae (1 species), Noctuidae (2 species) and Erebidae (1 species). Feeding guilds of larvae (known or strongly suspected) are: detritivores (13 species), polyphagous herbivores (3 species), oligophagous monocot-feeding herbivores (5 species), oligophagous dicot-feeding herbivores (3 species), monophagous herbivores (4 species, one of these specialising on ferns). For the remaining 3 species (*Microcolona* sp. A, *Ephestiopsis oenobarella* (Meyrick) and *Sigilliclystis insigillata* (Walker)) the life-histories are unknown.

Introduction

Hoare (2001) treated the adventive Lepidoptera newly recorded in New Zealand (henceforth NZ) since the annotated catalogue of Dugdale (1988). Of the 29 species discussed there, at least six are not considered to be established in NZ, including four probable vagrants that have not been collected since their original occurrence in this country (*Heteroteucha dichroella* Zeller, *Papilio xuthus* Linnaeus (one photographed since), *Cizara ardeniae* (Lewin), *Chasmina* sp.) and two species that were established but deliberately eradicated as potential pests (*Teia anartoides* Walker and *Orgyia thyellina* Butler). The remaining 23 species are probably established in NZ, except perhaps *Zomariana doxasticana* Meyrick (Tortricidae), which has not been recorded since 1999 and might be a sporadically establishing immigrant. Fox (1978) and Hoare (2001) discussed the means of arrival of adventive moths in NZ and that discussion is not repeated here. However, the geographical origins and feeding guilds of the newly recorded species are discussed in general terms below.

The current paper adds a further 31 species recorded as new to NZ from 2001 to 2017. Some of these were already known to Dugdale (1988) and Hoare (2001) but were not identified until more recently (*e.g.* the three *Lepidoscia* (s.l.) species (Psychidae)). A number of species discussed here have already been published as present in NZ (*e.g.* Patrick 2004, Hoare 2010a, Hoare 2011, Popay and Gunawardana 2011); the current paper is intended to bring together the information on all these species in a consistent format, give pointers for their identification and illustrate the adults, many of them for the first time in a NZ context. Details of first records of each species for NZ, distribution here and overseas and life history are given (where known). Only species known or believed to be established and breeding in NZ are treated here; one-off records thought to be of vagrants are omitted in order to keep this contribution to a manageable size.

Butterflies (Papilionoidea) are also omitted from detailed consideration in this paper but a brief update is provided here. Two species have become established in NZ since 2001. The Large White butterfly (*Pieris brassicae* (Linnaeus): Pieridae), a well known European pest of Brassicaceae, was detected in Nelson in May 2010 as larvae on nasturtiums (*Tropaeolum*) and became widespread in the city over the following summers. The Department of Conservation coordinated a ground-based eradication attempt from November 2012 onwards and this appears to have been successful, with the last butterfly being captured on 16 December 2014 (Phillips *et al.* 2016).

In August 2013, the Honshu White Admiral butterfly (*Limenitis glorifica* Fruhstorfer: Nymphalidae) from Japan was approved for release in NZ as a biological control agent for Japanese honeysuckle (*Lonicera japonica*), an abundant and widespread weed. The first releases took place in November 2015 in the Waikato region, with subsequent broods appearing in January and March 2016 at the release site (Paynter 2016). The butterfly appears to have established well and is beginning to spread (Q. Paynter pers. comm. 2017).

Family representation of newly recorded species

The family with the greatest number of newly recorded adventive species is Tineidae (5 species). Oecophoridae and Pyralidae each have four newly recorded species and Psychidae three species. Gelechiidae, Crambidae and Noctuidae have two newly recorded species each, while all remaining families (Glyphipterigidae, Coleophoridae, Depressariidae, Elachistidae, Cosmopterigidae, Blastobasidae, Tortricidae, Geometridae and Erebidae) each have a single newly recrded species. This representation by families in general accords with the predominance of the detritivore guild among newly established Lepidoptera (see below). All the Tineidae, Oecophoridae and Psychidae discussed here are essentially detritivores, along with at least two of the four Pyralidae (*Stericta carbonalis* (Guenée) and *Aglossa pinguinalis* (Linnaeus)).

Geographical origins of newly recorded species

Of the 31 species treated here, by far the largest number originate from Australia (19 species), with a further two species (*Erechthias capnitis* (Turner) and *Parochmastis hilderi* (Bradley)) from Norfolk Island. Nine species are essentially European or Palaearctic in origin but most of these have been spread widely throughout the world and five are present in Australia (*Coleophora deauratella* Lienig & Zeller, *Blastobasis marmorosella* (Wollaston), *Cosmopterix attenuatella* (Walker), *Aglossa pinguinalis* and *Ctenoplusia limbirena* (Guenée)). These five may well have come to NZ from Australia as well. A single species (*Symmetrischema striatella* (Murtfeldt)) is American in origin and is not known from Australia. The overwhelmingly Australian origin of recent arrivals corresponds with the findings of Hoare (2001: table 1) for adventive species added to the NZ list between 1988 and 2001. As noted there (Hoare 2001: 23-24), it can be hard to determine whether any given Australian moth arrived here as an import or as a result of migration or 'assisted passage' on prevailing weather systems. However, species with flightless females such as *Lepidoscia* sp. near *lainodes* (Psychidae) can safely be assumed to be accidental imports. Hoare (2001) reported two species of South-East Asian origin that had established in northern NZ as a result of accidental importation: *Artona martini* Efetov (Zygaenidae) and *Orgyia thyellina* Butler (Erebidae, formerly Lymantriidae). The latter was eradicated soon after its detection in 1996 but *Artona martini* is well established and spreading. No further South-East Asian species are reported in the current paper.

Host plant associations and feeding guilds of newly recorded species

Detritivores (species with larvae feeding on leaf litter, fungus, lichen, dead wood or dung) predominate among established adventive Lepidoptera in NZ (Hoare 2001: table 1), with 36 detritivorous species out of 112 recorded up to 2001 (32%). The pattern is reinforced in the newly recorded species, with 13 detritivores of the total of 31 (42%). Oligophagous herbivores are defined as those species feeding on more than one genus of plants in a single plant family or two closely related families (*e.g.* Fabaceae and Mimosaceae). These make up the next best represented group, with eight species: it is notable that five of these are monocot-feeders (16% of the newly recorded species). There were only five such monocot-specialists in the adventive fauna of 112 species recorded up to 2001 (4%) (Hoare 2001). Four species are believed to be monophagous (restricted to a single plant genus); one of these (*Musotima ochropteralis* (Guenée)) is a fern specialist, the only such species in the adventive fauna to date. (*Balanomis encyclia* Meyrick is very tentatively included as monophagous; it has only been reared once). The proportion of monophagous species among the new additions (13%) is similar to that in the previously known adventive fauna (20/112 species = 18%). There are three polyphagous herbivores among the newly listed species: *Isotenes miserana* (Walker), *Pantydia sparsa* Guenée and *Ctenoplusia limbirena* (Guenée).

(*Isotenes miserana* is partly detritivorous but has been counted here as a herbivore, since the larva frequently bores into fruit or feeds on living leaves). The 9.5% proportion of polyphagous species among the new additions is similar to the 12.5% (14/112) recorded for the adventive fauna up to 2001 (Hoare 2001). The life history is unknown for three of the 31 species treated here: *Microcolona* sp. A, *Ephestiopsis oenobarella* (Meyrick) and *Sigilliclystis insigillata* (Walker).

***Leptocroca sanguinolenta* (Oecophoridae): corrected first record**

Hoare (2001) incorrectly gave 23 June 1991 as the date of first NZ capture of the Australian oecophorine *Leptocroca sanguinolenta* Meyrick. There are three previous records: one taken in Symonds St, Auckland City, resting on a window by day on 25 June 1986, one attracted to light in Emily Place, Auckland City on 7 July 1987 and one indoors in Symonds St, 4 July 1990 (all NHNZ).

Methods and conventions

The following abbreviations are used for repositories of specimens mentioned in the text (all collections are in NZ unless otherwise stated):

AMNZ – Auckland Museum, Auckland; ANIC – Australian National Insect Collection, CSIRO, Canberra, Australia; BLNZ – Brian Lyford private collection, Queenstown; BPNZ – Brian Patrick private collection, Christchurch; EENZ – Eric Edwards collection, Wellington; MONZ – Museum of New Zealand Te Papa Tongarewa, Wellington; NHNZ – Neville Hudson private collection, Freemans Bay, Auckland; NZAC – New Zealand Arthropod Collection, Landcare Research, Auckland; PHEL – Plant Health and Environment Laboratory collection, Ministry of Primary Industries (MPI, formerly MAF), Auckland. The names of the authors are abbreviated as RJBH and NH.

Specimens in NHNZ are assigned an individual collection number and the information is stored in a personal database in Excel spreadsheets. Light-trapping records are also kept by NH for specimens not retained. Information derived from either of these sources is annotated '(NH database)'. All specimens currently in private collections are destined to be deposited in public collections in future. Label data for the figured specimens are given in Appendix 1.

Unless otherwise indicated, wingspans given are the range observed in NZ material of each species held in NZAC and NHNZ; overseas specimens were not measured but ranges from the literature are quoted for species where little NZ material is available for study. Wingspans are rounded to the nearest 0.5 mm. Percentages mentioned in the text are rounded to the nearest 0.5%.

Two-letter area codes for regions of NZ are as defined by Crosby *et al.* (1998).

TINEIDAE: HIEROXESTINAE

***Oinophila v-flava* (Haworth, 1828)**

Yellow V moth (Fig. 1)

Gracillaria v-flava Haworth, 1828. *Lepidoptera Britannica* [Part IV]: 530.

*NZ records and distribution***.** First record: 1 ♂, HB: Napier, Kennedy Park, emg. 31 Oct 2001 from *Eucalyptus* detritus, RJBH (NZAC) (Fig. 1). No further NZ records, but very likely established (see Remarks).

Overseas distribution. Central and southern Europe (where probably indigenous), introduced to Macaronesia, South Africa, California and the Juan Fernandez Islands; not known from Australia or the Pacific (Davis 1978, Pelham-Clinton 1985a).

Biology. In cool temperate climates (*e.g*. mainland Britain), the moth lives in cellars and outhouses and the larvae feed on mould and fungus, including the cellar-fungus *Zasmidium cellare* (Morrison 1968, Pelham-Clinton 1985a) and on mouldy wine corks. In warmer climates, larvae feed in bark (including phoenix palm, *Phoenix* spp) or decaying grass cuttings. In Britain, the moth is found in the open only on the Isles of Scilly, where larvae were found on the introduced NZ tree *Pittosporum crassifolium*, mostly under paper-thin bark that had detached from the trunk on otherwise healthy trees (Heckford 1987). Larva long and thin (up to 8.3 mm x 0.7 mm diameter), with a light reddish brown head and paler prothoracic plate, the rest of the body varying from transparent and glass-like with the gut showing dark grey to opaque white with the gut not visible; pinacula concolorous with the body (Heckford 1987, Davis 1978). The NZ specimen emerged from a random collection of *Eucalyptus* bark and leaf litter gathered in October.

Diagnosis. Wingspan 8.5-10 mm (Davis 1978). Combination of size and wing pattern (brown forewings with pair of transverse yellowish bands) is diagnostic among NZ tineids. Larva diagnosed by microscopic features (Davis 1978): proprioceptor setae MSD2 on T2 and T3 extremely long; much of integument covered by transverse rows of trispinulate tubercles; planta of proleg lacking marginal spines (present in *Opogona omoscopa* (Meyrick)).

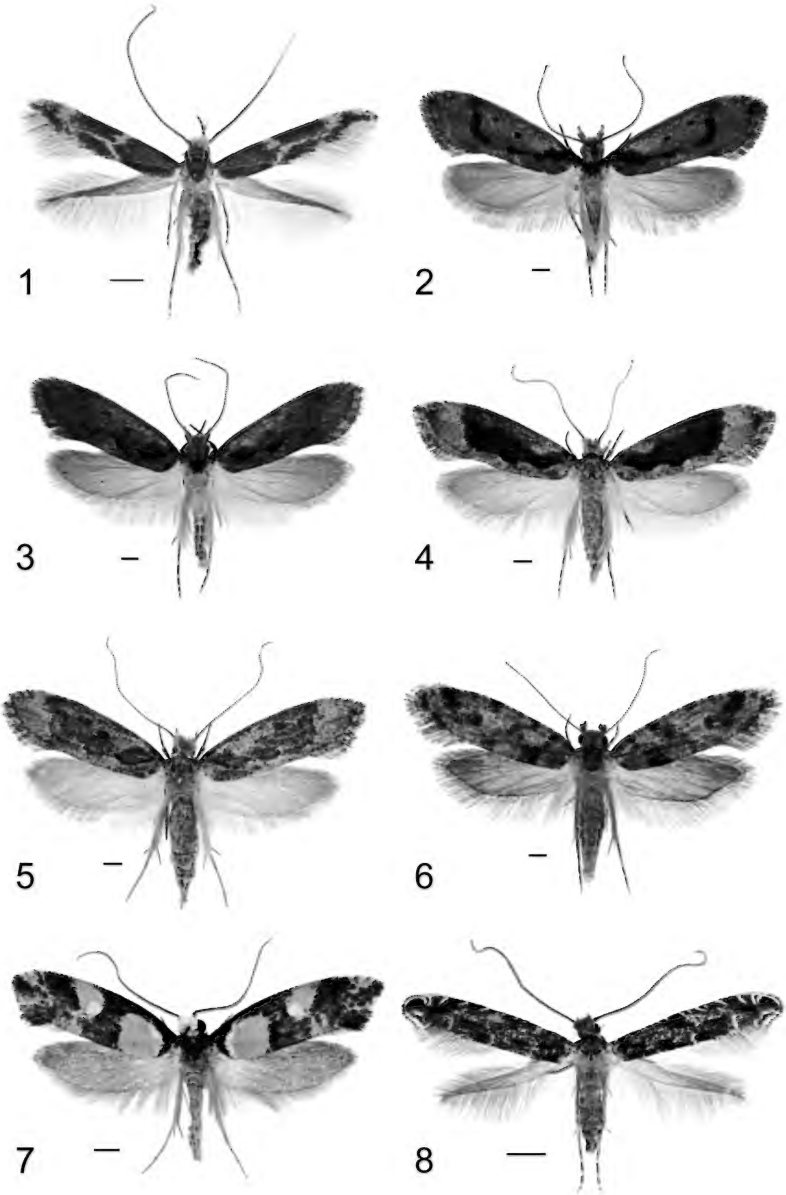
Remarks. Only one specimen of *Oinophila v-flava* has been found in NZ, but since this specimen came from an outdoors environment and was reared, the species is very likely to be established. It can be hard to detect *O. v-flava* as an adult, as noted by Powell (1964) and Davis (1978). The species was originally added to the NZ list without further details by Hoare (2010a).

TINEIDAE: ERECHTHIINAE

***Erechthias capnitis* (Turner, 1918)**

(Figs 2-5)

Tinea capnitis Turner, 1918. *Transactions of the Royal Society of South Australia* **42**: 288.



Figs 1-8. Tineidae: (1) *Oinophila v-flava* ♂. (2-5) *Erechthias capnitis*: (2-3) ♂♂; (4-5) ♀♀. (6) *Parochmastis hilderi* ♀. (7) *Monopis* sp. near *icterogastra* ♂. (8) *Oenoe* sp. A ♀. Scale bars 1 mm.

NZ records and distribution. First record: 2 specimens, AK: Devonport, Jan 1977, sticky trap (MAF, no collector given) (NZAC). Many reared from dead wood, Mt Albert, Auckland AK, late 1979, L.I.N. Roberts. Now common around Auckland and also recorded from Paihia and Whangarei (ND), Pukekawa, northern Waikato (WO) and recently from New Plymouth (TK). Likely to be more widespread.

Overseas distribution. Originally endemic to Norfolk Island (Turner 1918, Holloway 1977).

Biology. Adults collected or reared in NZ mostly September to February; a few recorded May to July. Reared from larvae in a variety of dry dead plant material, including wood of *Tibouchina*, *Eucalyptus* and *Tecoma*, a stump of *Dahlia excelsa*, *Uromycladium* rust galls on *Acacia* and old galls of an unknown gall former on *Ardisia crispa* (ten thousand yen plant). Native hosts include dead branches of *Coprosma,* dead bark of *Sophora chathamica*, twigs of *Knightia excelsa* and dead hanging leaves of *Cordyline australis* (reared specimens from all these hosts in NZAC). Larva undescribed. Adults come to light in small numbers.

Diagnosis. Wingspan 12-18 mm. Varies in forewing pattern: a range of forms is shown in Figs 2-5. The large transverse crescentic mark at 3/4 length of the forewing is characteristic. The endemic tineid *Trithamnora certella* (Walker) resembles the form of *E. capnitis* shown in Fig. 4. The female *T. certella* is a narrower-winged moth with a much paler, whitish ground colour, a whitish thorax and hindwings distinctly darkened beyond mid-length; in *E. capnitis* the thorax is usually ochreous to brown and the hindwings uniformly translucent whitish to pale grey. (Male *T. certella* is a very dark moth with blackish brown hindwings and does not closely resemble *E. capnitis*).

Remarks. Easily overlooked as an adult moth but rearing reveals it to be very well established and common in Auckland, especially in drier, more open habitats. The species was originally added to the NZ list without further details by Hoare (2010a). The male genitalia were illustrated by Bradley (1956).

TINEIDAE: HAPSIFERINAE

***Parochmastis hilderi* (Bradley, 1956)**

(Fig. 6)

Norfolkia hilderi Bradley, 1956. *Bulletin of the British Museum* (*Natural History*) *Entomology* **4**(4): 162-163.

NZ records and distribution. First record: 1 specimen, AK: Freemans Bay, Hayden St, Heath trap, 1-2 Feb 2012, NH (NHNZ). Subsequently found in small but increasing numbers at the same locality every year, either in Heath trap or indoors. One on trunk of *Acacia mearnsii* in Ken Maunder Park, New

Lynn on 12 Jun 2017 and others in Blockhouse Bay Recreational Reserve in 2018 (both S.E. Thorpe) show moth has spread, at least within Auckland.

Overseas distribution. Originally endemic to Norfolk Island (Bradley 1956, Robinson and Nielsen 1993).

Biology. Adult in all months from October to August, being especially frequent in autumn (NH database). Life history unknown but Norfolk Island type series was collected on the bark and rotten wood of a fallen *Araucaria heterophylla* (Norfolk Island pine), near empty pupa cases believed to belong to this species (Bradley 1956: 163). The female ovipositor has a strongly sclerotised piercing tip, suggestive of an atypical biology (Robinson and Nielsen 1993). Norfolk Island pine is a very commonly planted tree in urban Auckland.

Diagnosis. Wingspan 12-15 mm (NZ specimens). Could be confused with the smallest specimens of *Lindera tessellatella* Blanchard (usually a much larger moth, with wingspan 13-34 mm); it can be distinguished by the distinctly dark-banded antennae (antennae unicolorous yellowish or occasionally grey in *L. tessellatella*), by the broadly spatulate 3rd segment of the labial palpus (segment cylindrical in *L. tessellatella*) and by the forewing pattern, which has two conspicuous quadrate marks on the dorsum at 1/3 and 2/3, absent in *L. tessellatella*. The rare endemic tineids *Archyala terranea* (Butler) and *A. opulenta* Philpott have the head covered with narrow hair-like scales (lamellate scales in *Parochmastis* and *Lindera*) and labial palpus 2nd segment with numerous long erect hair scales beneath, 3rd segment narrow and cylindrical (*Parochmastis* has erect but short and lamellate scales beneath the palpus 2nd segment; *Lindera* has a smooth-scaled palpus 2nd segment).

Remarks. The genus *Parochmastis* Meyrick was redescribed in detail by Robinson and Nielsen (1993). This is the third species of micro-moths endemic to Norfolk Island to have become established in NZ, after *Anisoplaca cosmia* Bradley and *Erechthias capnitis* (see above). It has only been taken in a few localities so far but is likely to be overlooked. The moths run even more actively than other Tineidae across surfaces (including walls, ceilings and people) and they have only been observed flying in short, skipping flights (NH pers. obs.).

TINEIDAE: TINEINAE

***Monopis* sp. near *icterogastra* (Zeller, 1852)**

(Fig. 7)

NZ records and distribution. First record: 1 ♂, AK: Freemans Bay, Hayden St, Heath Trap, 3-4 Feb 2016, NH (NHNZ). Nineteen more in 2016-2017 at the same site (12 retained; NHNZ, NH database). One to u.v. light trap, Longfellow Parade, Glen Eden AK, 18-19 Feb 2018, RJBH (NZAC).

Overseas distribution. Endemic to Australia: Queensland, New South Wales, Australian Capital Territory, South Australia, Victoria and southwestern Western Australia (specimen records in ANIC: E.D. Edwards pers. comm.); not known from Tasmania.

Biology. Adults mainly February to May (Freemans Bay), singletons in September and November (NH database). As noted by Robinson and Nielsen (1993: 168), two sibling species have been confused under the name *Monopis icterogastra*. The biology of the two species differs: the true *M. icterogastra* is larviparous, laying first-instar larvae instead of eggs; the unnamed species is a conventional egg layer (Robinson and Nielsen 1993). In the wild, *M. icterogastra* (*sensu lato*) has been reared from feather-lined birds' nests; Hindwood (1951) recorded it (under the name *nivibractella* Walker, a synonym) from nests of estrildid finches. Estrildids do not occur wild in NZ but nests of other small passerine birds are very likely to be suitable; there is a sparrow's nest in the roof adjacent to the light trap where the Glen Eden specimen was collected. [The true *M. icterogastra* has been reared in captivity on woollen flannel; young larvae made portable cases from the feeding substrate consisting of two oval pieces joined at the sides with silk and open at each end (Scott 1863)].

Diagnosis. Wingspan 13-20 mm. Wing pattern diagnostic among NZ tineids (Fig. 7). Distinguished from true *M. icterogastra* by the hyaline spot of the forewing, which is covered by white scales and lies within the white costal blotch; in *M. icterogastra* the hyaline spot is covered in tiny grey scales and lies at the edge of the costal blotch (as noted in the original description by Zeller 1852) (M. Horak pers. comm. 2017).

Remarks. This is the fourth adventive species of *Monopis* Hübner to be recorded in NZ, after the cosmopolitan *M. crocicapitella* (Clemens) and the Australian *M. ethelella* (Newman) and *M. argillacea* (Meyrick). It would be of great interest to study the ecology of this genus in NZ, where the few endemic species of *Monopis* are poorly known and seldom collected, and to know to what extent the introduced taxa make use of native habitats and the nests of endemic birds. Among the endemic species, at least *Monopis ornithias* (Meyrick) has been reared from birds' nests (Meyrick 1888). On Motunau Island, Canterbury, Hawke and Clark (2010) recorded *M. crocicapitella* and *M. ethelella* (but no endemic *Monopis*) in numbers in nest burrows of the Little Blue Penguin (*Eudyptula minor* (Forster), a native species shared with Australia). [The synonymy of *nivibractella* with *icterogastra* follows Robinson and Nielsen (1996); the synonymy was implied but not formally listed by Robinson and Nielsen (1993).]

TINEIDAE: SUBFAMILY UNKNOWN

***Oenoe* sp. A**

(Fig. 8)

NZ records and distribution. First record: 2 specimens, CL: Little Barrier Island, 7-9 Feb 1974, J.S. Dugdale (NZAC). Subsequently from ND: Whakaangi near Hihi and Mangawhai Heads; AK: Albany, Freemans Bay, Meadowbank, Waiatarua (Spragg's Bush), Kakamatua Inlet, Laingholm, Piha, Titirangi, Clevedon and the Noises Islands (Motuhoropapa Is.); CL: Mahakirau Forest Estate.

Overseas distribution. Presumed endemic to eastern Australia: New South Wales and Queensland (specimens in ANIC).

Biology. Adults in NZ late November to late March. Life history unknown (not known for any species of *Oenoe* (Robinson and Nielsen 1993)).

Diagnosis. Wingspan 8-10 mm. A small, very narrow-winged tineid with forewings black, speckled white and orange, and a distinctive wing pattern of *ca* 14 silvery costal strigulae, two more distinct silvery strigulae on the dorsum at *ca* 1/2 and 3/4 wing length and a subapical longitudinal black streak bordered above and below by orange scales and tipped by a silvery spot (Fig. 8). Easily recognised when fresh.

Remarks. Placement of this unnamed species in the genus *Oenoe* Chambers as defined by Robinson and Nielsen (1993) has been confirmed by dissection of male and female genitalia of NZ specimens. The female has the highly characteristic signum on the corpus bursae likened by Robinson and Nielsen (1993) to a surgical stitch. In NZ, it comes in small numbers to actinic and mercury vapour light, usually in or near native forest.

PSYCHIDAE

***Lepidoscia heliochares* (Meyrick, 1893)**

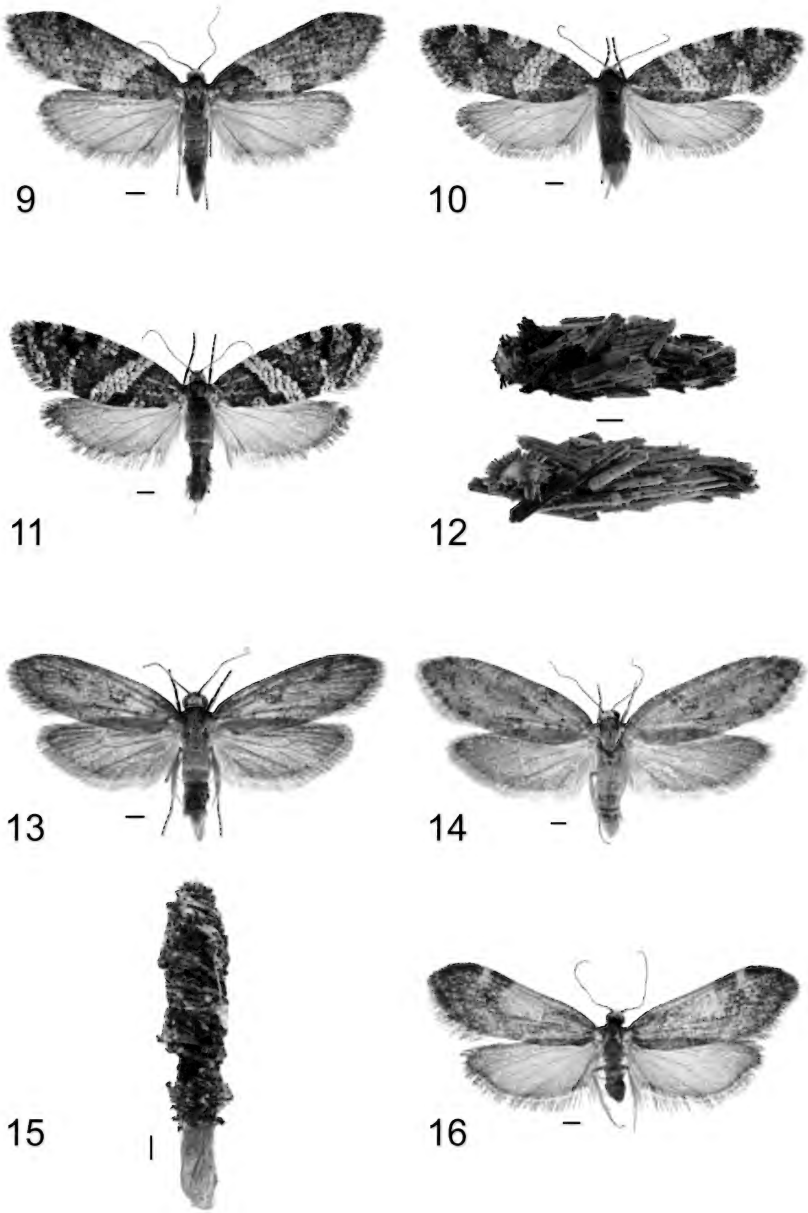
(Figs 9-12)

Xysmatodoma heliochares Meyrick, 1893. *Proceedings of the Linnean Society of New South Wales* (2nd series) **7**: 498-499.

NZ records and distribution. First record: 1 ♂, AK: Henderson, to light, 25 July 1974, J.S. Dugdale. Apparently spread very rapidly: already recorded in Christchurch (MC) in 1982. Now widespread and common from Northland ND to Dunedin DN and inland in the South Island at least as far as Alexandra CO.

Overseas distribution. Endemic to Australia: S. Queensland (Brisbane), New South Wales, A.C.T. and South Australia (specimens in ANIC).

Biology. Adults in NZ to light in winter, early July to mid-September. Earlier part of life history not observed; full-grown larva in a roughly conical case 9-12 mm long, consisting of a layer of finely comminuted plant material overlain by larger sections of plant material 2-3 mm long arranged longitudinally (Fig. 12). Case-making not observed and plant material used not identified but larger sections often include tubular pieces of plant stem;



Figs 9-16. Psychidae: (9-12) *Lepidoscia heliochares*: (9) ♂; (10-11) ♀♀; (12) larval cases. (13-15) *Lepidoscia protorna*: (13) ♂; (14) ♀; (15) larval case. (16) *Lepidoscia* sp. near *lainodes* ♂. Scale bars 1 mm.

on Kaitorete Spit, where cases were collected under dead logs on the dunes, larger sections appear to be small pieces of dead wood. From the cases examined, larva seems to prefer plant material that is rough and grooved. Presumed to be a plant-litter feeder.

Diagnosis. Wingspan 15-22 mm. Pale broad forewing fascia at about 1/3 wing length that contrasts with darker basal area of the wing is diagnostic among winter-flying micro-moths in NZ, although there are numerous similar species in Australia.

Remarks. This species and *L. protorna* (see below) are the 'two undescribed species' of Psychidae referred by Dugdale (1988: 69) in his catalogue of NZ Lepidoptera to 'Genus near *Alytopistis* Meyrick' (*cf.* Hoare 2010a: 366). *Alytopistis* was described by Meyrick (1920) in Tortricidae for *Tinea tortricitella* Walker. In relating the *Lepidoscia* species to this genus, Dugdale anticipated the treatment of *Alytopistis* as a junior synonym of *Ardiosteres* Meyrick (Psychidae) by Nielsen and Edwards (1996: 34), followed by Sobczyk (2011). However, Gilligan *et al.* (2014) retained *Alytopistis* in Tortricidae (Tortricinae). The family placement of *A. tortricitella* needs to be revisited in the light of this ongoing confusion.

The identification of the three *Lepidoscia* Meyrick species present in NZ was arrived at by comparison of NZ material with the type material of Australian Psychidae held in the BMNH. As noted by Hoare (2011), *Lepidoscia* might be a composite genus: for example, as currently constituted (Nielsen and Edwards 1996), it contains some species with winged and some with wingless females. *Lepidoscia heliochares* is typically found in gardens, parks, coastal dunes and other rather open situations.

***Lepidoscia protorna* (Meyrick, 1893)**

(Figs 13-15)

Xysmatodoma protorna Meyrick, 1893. *Proceedings of the Linnean Society of New South Wales (*2nd series) **7**: 495-496.

NZ records and distribution. First record: 1 ♂, AK: Mt Eden, to light, 7 Nov 1978, P.A. Maddison (NZAC) (date wrongly given as 1979 in Hoare (2011)). Subsequently from AK: Albany, Titirangi, Henderson, St Johns, Puketutu Island; ND: Spirits Bay, Mangawhai Heads, Paihia, Maitahi, Ngawha Springs, Whakaruangangana (near Kaikohe) (Hoare 2011); CL: Stony Bay (NH database), BP: Te Aroha; HB: Te Mata; TK: New Plymouth; undoubtedly overlooked elsewhere due to lack of recording.

Overseas distribution. Endemic to Australia: New South Wales, Victoria, Tasmania (specimens in ANIC).

Biology. Adults mostly late December to March but first NZ specimen in early November and one Auckland record from 3rd May (S.E. Thorpe). Earlier larval instars not observed; case of full-grown larva *ca* 20 mm long,

with layer of finely comminuted plant fragments covered by spirally arranged cylindrical pieces of plant stem *ca* 3 mm long (resembling minute logs) (Fig. 15). Larva generally feeds on leaf litter on the ground (J.S. Dugdale pers. comm.) but a colony existed on the roof of RJBH's former house in Titirangi AK, where leaf litter and lichens were both abundant.

Diagnosis. Wingspan: 20-28 mm. Diagnosed by combination of size, flight time, yellowish white head contrasting with grey thorax, and speckled forewing pattern (outwardly oblique streak from costa just before middle often the only conspicuous marking although this too might be obscure).

Remarks. This species was added to the NZ list by Hoare (2010a) and was discussed further and illustrated in a later publication (Hoare 2011). Sexual dimorphism is more pronounced than in *L. heliochares*: females of *L. protorna* are distinctly larger and longer-winged than males and often have the oblique costal forewing mark narrower and less conspicuous. This species is now common and often found in native forest as well as gardens and parks.

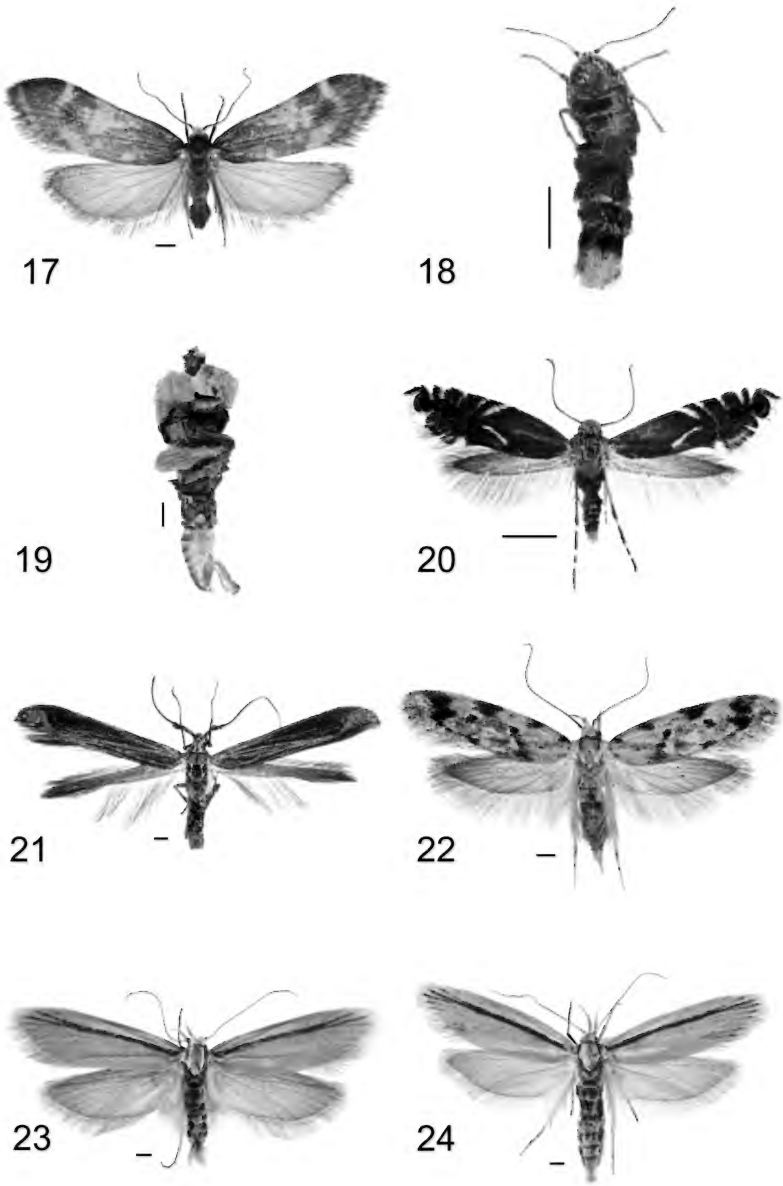
***Lepidoscia* sp. near *lainodes* Meyrick, 1921**

(Figs 16-19)

NZ records and distribution. First record: empty cases, AK: Mt Eden gardens, 14 Sep 1982, P.A. Maddison (3 cases in NZAC). Reared in 1983 from cases collected in Titirangi by D. Elliott and R. Kleinpaste. Subsequently from AK (*e.g.* Albany, Auckland CBD and Freemans Bay (NHNZ), Huia, Titirangi, Mt Albert, Orakei, St Johns, St. Heliers and Hunua Ranges (Waharau Regional Park)) and, more recently, Te Awamutu WO and Te Aroha BP.

Overseas distribution. Unknown; believed to be an Australian endemic.

Biology. Adults in winter (mid-June to late July); males attracted to light and also seen flying freely *ca* 0900 h and assembling to a female later in the day (time not recorded). Female wingless but emerges from her case to call male. Early instars not observed; case of full-grown larva *ca* 6-8 mm long, with a layer of finely comminuted plant fragments covered by larger fragments arranged transversely; larger fragments are often cylindrical sections of plant stem as in *L. protorna*, but flatter flake-like pieces (probably pieces of stem from non-woody plants) also used; distal 1/3-1/2 of case may be covered in these flakes (Fig. 19). Case material and construction more variable than in the other two *Lepidoscia* species; one case examined incorporates setiferous scales from a fern rachis (possibly mamaku, *Cyathea medullaris*). No consistent differences observed between cases of males and females. Case attached at right angles to the substrate. Larvae wander in their cases over vegetation, walls and fences, probably chiefly grazing on microscopic algae; in wetlands, often on oioi (*Apodasmia similis*). One larva found at Mt Albert scraping ootheca of South African mantis, *Miomantis caffra* Saussure (moth not reared, case in NZAC).



Figs 17-24. Psychidae, Glyphipterigidae, Coleophoridae, Oecophoridae: (17-19) *Lepidoscia* sp. near *lainodes*: (17) ♂; (18) ♀; (19) larval case. (20) *Glyphipterix simpliciella* ♂. (21) *Coleophora deauratella* ♂. (22) *Opsitycha squalidella* ♀. (23-24) *Philobota* sp. A: (23) ♂; (24) ♀. Scale bars 1 mm.

Diagnosis. Wingspan (male): 13-18 mm. Elongate subtriangular pale cloud along the middle of the forewing costa usually contrasts quite strongly with the brownish grey ground colour of the wing and is diagnostic. Female unlikely to be found away from characteristic case.

Remarks. This species was listed by Dugdale (1988: 69) as an undetermined species of an indeterminate genus with the comment 'origin obscure, possibly Taiwan'. However, comparison with material in the BMNH and ANIC indicates that this is almost certainly an Australian species of *Lepidoscia*. Meyrick (1921) described *Lepidoscia lainodes* from a single specimen reared by Dodd in May from Toowong, Brisbane, Queensland. There are two male specimens in ANIC matching the photo of the *L. lainodes* holotype in wing pattern: both from Wilton, N.S.W., collected by V.J. Robinson on 17 Apr 1967 and 19 Mar 1974. Because true *L. lainodes* appears to lack the distinct uninterrupted pale cloud along the forewing costa and because the flight time appears to be different (especially if the Wilton specimens are *L. lainodes*), the species established in NZ is believed to be a different taxon. No specimens closely matching the NZ species were found in ANIC or BMNH and it is presumed to be undescribed. However, because of its superficial similarity to *L. lainodes*, it is thought likely to originate from Australia and to have been overlooked there. The conspicuous upright larval case is now a common sight in the northern North Island.

GLYPHIPTERIGIDAE: GLYPHIPTERIGINAE

***Glyphipterix simpliciella* (Stephens, 1834)**

Cocksfoot Moth (Fig. 20)

Heribeia simpliciella Stephens, 1834. *Illustrations of British Entomology; Haustellata* vol. IV: 263.

NZ records and distribution. First record: 1 ♀, HB: Boundary Stream Reserve, Shine Falls Track, 30 Nov 2000, RJBH, G. Hall, C. Yong, T. Sirey (NZAC). Subsequent records: Port Waikato WO, 20 November 2010, NH (5 specimens, NHNZ), 2 specimens, near Whatipu AK, 20 Nov 2011 (NZAC, NHNZ); now abundant on Tamaki Campus, Auckland University, St Johns. Recently photographed in Wellington WN (Karori and Thorndon) and Tauherenikau near Featherston (WA) (per iNaturalist NZ). Probably common and widespread throughout North Island but overlooked.

Overseas distribution. Throughout Europe including Iceland, extending to Asia Minor and North Africa (Pelham-Clinton 1985b).

Biology. In NZ, adults in November. Fly by day around the host plants and visit flowers such as buttercup (*Ranunculus* spp), manuka (*Leptospermum scoparium*) and ox-eye daisy (*Leucanthemum vulgare*); like other species of *Glyphipterix* Hübner they wave their wings slowly up and down when at rest. According to Chopra (1925), most active from 1400-1700 h. Life history documented in detail by Chopra (1925) (as *Glyphipteryx* [sic] *fischeriella*, a

synonym) and summarised by Pelham-Clinton (1985b). Eggs laid on the seed-heads of the host plant; one female can lay up to 30 eggs (Chopra 1925). Larva feeds on seeds of cock's-foot grass (*Dactylis glomerata*) or tall fescue (*Festuca arundinacea*); both have been introduced to NZ. Larva described in detail by Chopra (1925); briefer description by Pelham-Clinton (1985b) summarised here: 'Head shining black; prothoracic plate brown ... body greenish or yellowish white with small dark pinacula; a narrow transverse dorsal plate on abdominal segment 9 and anal plate dark brown.' When full-grown in mid-summer, leaves seed-head and enters stem via a small hole, usually under an upper leaf-sheath (Pelham-Clinton 1985b); in captivity, can pupate in eaten-out seeds or in panicle between seeds (Chopra 1925). Larva spins a whitish cocoon in which it overwinters, pupating in spring.

Diagnosis. Wingspan 6-9 mm (Pelham-Clinton 1985b; in NZ, 6-7 mm). Presence of only 5 costal forewing strigulae distinguishes *G. simpliciella* from all endemic *Glyphipterix* species except *G. morangella* Felder & Rogenhofer and *G. brachydelta* Meyrick. In *G. morangella* (a rare species, known from ND, TO, NN, CH), 3rd (middle) strigula is closer to 4th than to the 2nd; in *G. simpliciella*, the 3rd strigula is about equidistant between 2nd and 4th. Also, in *G. morangella*, strigula in middle of forewing dorsum only distinct towards its apex (base obscured by forewing ground colour); in *G. simpliciella* this dorsal strigula is distinct to dorsum. In *G. brachydelta* (a local species, known from WN and NN), strigula in centre of forewing dorsum much broader than any of costal strigulae; in *G. simpliciella* this dorsal strigula is about same width as costal strigulae. *Glyphipterix brachydelta* only recorded in February and March, while *G. simpliciella* occurs in November.

Remarks. This moth can be a minor pest of cock's-foot grass grown for seed, as indicated by Chopra (1925); however, he noted marked differences in the level of damage on plants of different origin. There seem to be no records as yet of conspicuous damage caused by the larvae in NZ. The earliest known NZ specimen remained overlooked and unidentified in NZAC for some time due to confusion with small endemic *Glyphipterix* species, as detailed above.

COLEOPHORIDAE

***Coleophora deauratella* Lienig & Zeller, 1846**

(Fig. 21)

Coleophora deauratella Lienig & Zeller, 1846. *Isis oder Encyclopaedische Zeitung von Oken, Leipzig* **39**(3/4): 295.

NZ records and distribution. First record: 1 specimen, AK: St Johns, Tamaki Campus of Auckland University, beaten from *Trifolium pratense*, 27 Oct 2016, S.E. Thorpe. Subsequently several at same locality, 2016-2017, in small numbers among *T. pratense* (in NZAC and PHEL). Now known to be abundant throughout both main islands of NZ (Chynoweth *et al.* 2018).

Overseas distribution. Native to Europe, where very widespread; also in Asia Minor and Lebanon; introduced to Tasmania and northeastern North America (Landry 1991, Emmet *et al*. 1996).

Biology. Adults from late October to January in NZ, flying in sunshine by day. The Auckland specimens (mostly female) were either beaten or swept from *Trifolium pratense* or found at rest on that plant. Life history summarised by Emmet *et al*. (1996): eggs are laid on the florets of red clover (*Trifolium pratense*); the larva bores through the florets and feeds on the green developing seeds. In the fourth instar, it spins a silken case inside a floret, which the larva later shortens: the completed case is *ca* 6 mm long, tubular, stained dark red-brown towards the front; the front half is enclosed within the floret and the distal half (which remains white) protrudes. Larva full-fed in late summer and overwinters in the case (in the seedhead or on the ground), pupating in spring. Larva described as follows (summarised from Emmet *et al*. 1996: 249): Head brown; prothoracic plate brown with median sulcus, broadly black laterally and posteriorly; other thoracic plates black; thoracic legs pale yellowish brown; body brownish yellow, abdominal segments paler; anal plate pale yellow. Known alternative host plants (see Landry 1991, Landry and Wright 1993) are alsike clover (*Trifolium hybridum*), zigzag clover (*T. medium*) and haresfoot trefoil (*T. arvense*), all of which occur in NZ. White clover (*T. repens*) is also occasionally attacked during outbreaks (Landry and Wright 1993).

Diagnosis. Wingspan 9.5-15.5 mm (Landry 1991: a narrower range of 10.5-12.5 mm is given by Emmet *et al*. 1996 for the British Isles). Superficially very similar to the other two metallic bronzy green *Coleophora* Hübner species present in NZ, *C. alcyonipennella* (Kollar) and *C. mayrella* (Hübner), both of which feed on white clover (*Trifolium repens*). In *Coleophora mayrella* the antennae are distinctly black and white ringed beyond the basal 2/5 (basal 2/5 thickened with bronzy scales in both sexes); *C. deauratella* has just the apical 1/5 of the antenna white and not ringed. *Coleophora alcyonipennella* has antennal coloration as in *C. deauratella* but female of *C. deauratella* has the antennae very conspicuously thickened with scales to 1/4; *C. alcyonipennella* has the thickening inconspicuous and reaching only to 1/8. The ovipositor in *C. deauratella* (usually extruded in set specimens) is narrow-triangular with a bluntly rounded apex and a dark dorsal line along the edge of both ovipositor lobes where they meet; that of *C. alcyonipennella* is apically ‘pinched’ with a small notch between the lobes and lacks a black dorsal line. Males of both *C. deauratella* and *C. alcyonipennella* have only the scape and the proximal portion of the antennal flagellum thickened with scales and, while the thickening is more pronounced in *C. deauratella*, the difference is relative and, except for reared material, it is best to dissect out the genitalia to confirm the identity. Genitalia of both species were illustrated by Stübner (2007).

Remarks. This species, which can be a pest of cultivated red clover (Landry 1991, Landry and Wright 1993), is already well established, widespread and abundant in NZ (Chynoweth *et al.* 2018); although none of the older specimens of metallic Coleophoridae examined in collections proved to be *C. deauratella*, it must have been overlooked here for some time.

OECOPHORIDAE: OECOPHORINAE

***Opsitycha squalidella* (Meyrick, 1884)**

(Fig. 22)

Philobota squalidella Meyrick, 1884. *Proceedings of the Linnean Society of New South Wales* **8**: 496.

Borkhausenia morella Hudson, 1939. *A supplement to the butterflies and moths of New Zealand*: 444-445. **Syn. n.**

NZ records and distribution. First record: 1 ♀, AK: Onehunga, date unknown but 1939 or before, A.J. Hipwell (holotype of *Borkhausenia morella* Hudson, presumed lost). Subsequent records: 8 ♂♂, AK: Papakura, Ponsonby, Freemans Bay, 1980-2009 (NHNZ); HB: 3 ♀♀, Napier, Kennedy Park, to light, 2 Dec 2000 (NZAC). Other specimens seen but not collected, the latest to light, Freemans Bay AK, 21-22 Dec 2016 (NH database).

Overseas distribution. Endemic to Australia: central and southern New South Wales, A.C.T., Victoria, Tasmania, South Australia and southwestern Western Australia (Common 2000).

Biology. Adults to light in NZ October to December. Life history unknown but, in common with most members of the *Barea* group of Oecophorinae in Australia, probably a detritivore, with larvae feeding on leaf litter or possibly dead wood or other dead vegetable matter (*cf.* Common 2000).

Diagnosis. Wingspan 13.7-19.1 mm (Common 2000) (NZ specimens 14.5-17.5 mm). The wing pattern (Fig. 22) is diagnostic in a NZ context.

Note on synonymy. The holotype of *Borkhausenia morella* Hudson, collected by A.J. Hipwell at Onehunga AK, probably in the mid-1930s, has apparently been lost. It was not found by Dugdale (1988) in Hudson's collection in MONZ and does not appear to be among the many Hipwell Lepidoptera in NZAC. However, Hudson's description of external characters and his figure (Hudson 1939: 444-445 and pl. lxi fig. 31) perfectly match *O. squalidella* and, since this species has subsequently been found in Auckland and in Napier (identity confirmed by examination of male genitalia), there is little doubt that the synonymy (foreshadowed by Common 2000) is correct. For that reason, and in accordance with ICZN articles 75.2 and 75.3, we do not here designate a neotype.

Remarks. Until Edward Meyrick's death in 1938, G.V. Hudson sent specimens of new species to him to keep and name but, in the case of

Hipwell's specimen, he was probably awaiting capture of a duplicate so that one specimen could be retained in NZ (probably Hipwell wanted his specimen returned). When Meyrick died, Hudson named several species (including *Borkhausenia morella*) from unique examples and made errors in the process due to his unfamiliarity with overseas faunas and his assumption that the specimens belonged to indigenous species (*cf*. Hoare (2010b: appendix 1) on *Izatha griseata* Hudson (= *Anarsia dryinopa* Meyrick)).

The genus *Opsitycha* Meyrick was redescribed in detail and illustrated by Common (2000: 112-116), who recognised one unnamed species from Queensland as the only congener of *O. squalidella*. *Opsitycha squalidella* appears to be distinctly scarce and local in NZ but is clearly established, at least at low density.

***Philobota* sp. A (sp. 5 of ANIC)**

(Figs 23-24)

NZ records and distribution. First record: larvae among grasses, WO: Hamilton, Ruakura Research Centre (AgResearch), Feb 2010, A. Popay (♀ emg. 14 Aug 2010 in NZAC). Subsequently larvae and adults found in varying numbers at this site and nearby (some specimens in NZAC).

Overseas distribution. Endemic to Australia: New South Wales (*e.g.* Wollongong, Burrill Lake and Wilton; specimens in ANIC).

Biology. Adults light-trapped between 1 October and 3 December at Ruakura (Gerard 2013). Most reared specimens emerged in captivity in October but with the single August record mentioned above. Life history not observed in Australia but described briefly in NZ (Popay and Gunawardana 2011, Gerard 2013): larvae probably present from summer through to late winter, feeding on perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*), making characteristic silken tunnels with 'chimneys' that protrude above ground and incorporate grass and debris. The natural host plants must be Australian grasses, so the host range can be expected to be fairly wide within Poaceae.

Diagnosis. Wingspan 21-28 mm. Wing pattern (Figs 23-24) distinctive in a NZ context. Both forewings and hindwings are glossy and reflective, and the very long labial palpi with an extremely narrow and acute apical segment are unlike those of other oecophorine genera found in NZ. Differences between this species and *Philobota chionoptera* are detailed under that species, below.

Remarks. The identification of this species as a known but unnamed taxon standing in ANIC under the code 'ANIC5' was confirmed through DNA barcode-matching with specimens sequenced for BOLD (Barcode of Life Database) (D. Gunawardana pers. comm. 2012). It is interesting that two grass-feeding species of *Philobota* Meyrick apparently became established in NZ at about the same time; both were first recorded in 2010, although in

widely separated localities. Both belong to the *P. hydara* group of Common (1997). Other grass-feeding species of *Philobota* can reach pest status in pastures: the best known example is *P. productella* (Walker); Common (1997: 266-267) provides a useful summary of the biology of that species.

***Philobota chionoptera* Meyrick, 1884**

(Fig. 25)

Philobota chionoptera Meyrick, 1884. *Proceedings of the Linnean Society of New South Wales* **8**: 472 (key), 494.

NZ records and distribution. First record: 1 ♂, HB: Napier, near port, 30 Dec 2010, light trapping, B.H. Patrick & family (NZAC; genitalia on slide NZAC Oec. 676). Subsequently 4, HB: near research house at Cape Kidnappers Sanctuary, 7 Jan 2011, B.H. Patrick (Gerard 2013) (BPNZ).

Overseas distribution. Endemic to Australia: central and southern Queensland, New South Wales, A.C.T. and Victoria (Common 1997).

Biology. Adults in NZ late December to early January. Larvae probably have similar habits to those of *P.* sp. A (see above); recorded host plant in Australian pastures is Bermuda grass, *Cynodon dactylon* (Common 1997), but as with *P.* sp. A, can be expected to feed on a number of Australasian and European Poaceae.

Diagnosis. Wingspan 20-26 mm (Meyrick 1884). Sexually dimorphic: male almost unmarked, with pure white forewing except for blackish costal streak: unlikely to be confused with any other NZ gelechioid. Female has less distinct brownish costal streak as well as brownish longitudinal streak through cell and could possibly be confused in NZ with *P.* sp. A but that species has no brown costal streak, at most some faint brown scaling near but not touching the costa.

Remarks. Since this species was found in two well-separated locations near Napier and several specimens were taken, it is presumed to be established, although not sought since the original captures in 2010-2011. It might have been imported accidentally to the port of Napier and spread from there.

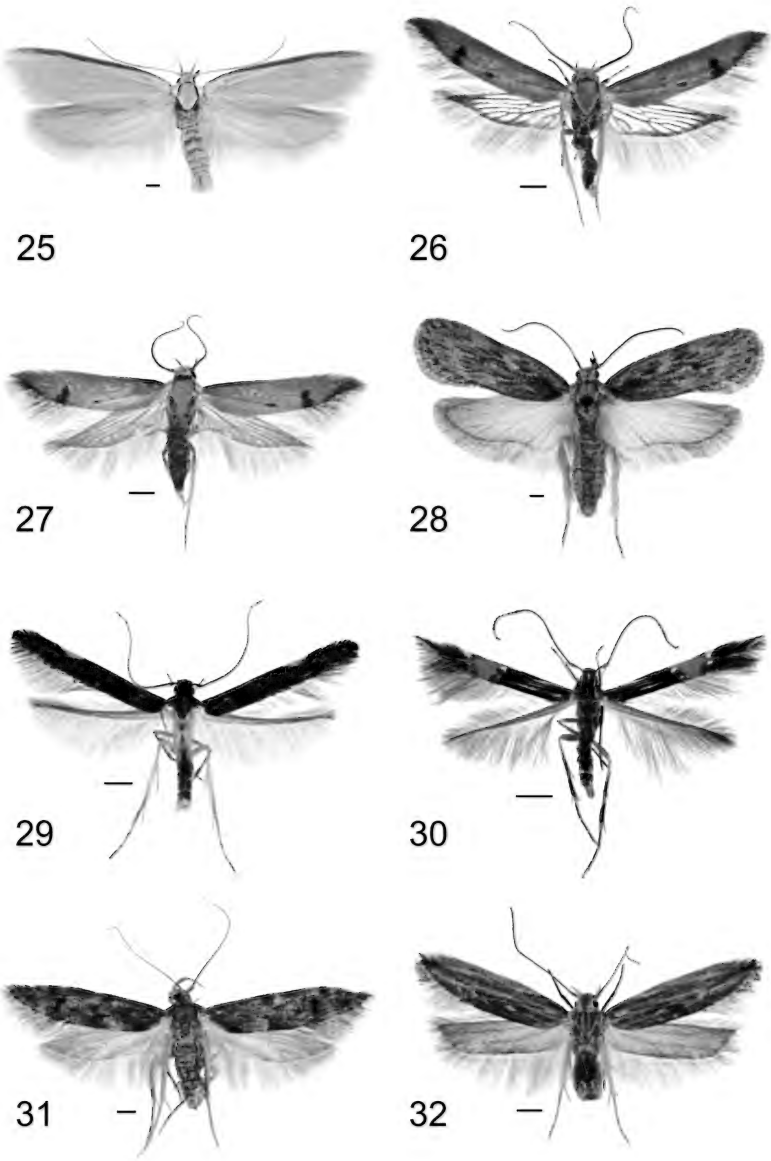
***Tachystola hemisema* (Meyrick 1885)**

(Figs 26-27)

Ocystola hemisema Meyrick, 1885. *Proceedings of the Linnean Society of New South Wales* **9**: 1060 (key), 1063.

NZ records and distribution. First record: 1 ♂, AK: Freemans Bay, 2-3 Feb 2008, NH (NHNZ). Now common at this site (NH database). Subsequently (from 2013) in moderate numbers in m.v. light trap at Redvale, Albany AK (NZAC), and at m.v. light in Glen Eden AK (NZAC).

Overseas distribution. Endemic to Australia: Queensland, New South Wales, A.C.T., Victoria, South Australia and Western Australia (Common 1997,



Figs 25-32. Oecophoridae, Depressariidae, Elachistidae, Cosmopterigidae, Blastobasidae, Gelechiidae: (25) *Philobota chionoptera* ♂. (26-27) *Tachystola hemisema*: (26) ♂; (27) ♀. (28) *Depressaria radiella* ♂. (29) *Microcolona* sp. A ♂. (30) *Cosmopterix attenuatella* ♂. (31) *Blastobasis marmorosella* ♀. (32) *Symmetrischema striatella* ♂. Scale bars 1 mm.

ANIC specimens). A *Tachystola* Meyrick species tentatively identified as *T. hemisema* has been established in California, U.S.A. since 2013 (per Bug Guide website, *www.bugguide.net*): see Remarks. [BMNH female labelled 'Astrolabe Range, New Guinea' (Common 1997: 81) is perhaps mislabelled].

Biology. Adults in NZ from September to May, particularly in spring and autumn, suggesting two annual broods. In Australia, reared from larvae feeding between adjacent dead leaves of a *Eucalyptus* sp. on a fallen branch, and from leaf litter of *Eucalyptus sideroxylon* (specimen labels in ANIC). According to Common (1997), larvae of this species (like those of *T. oxytora* (Meyrick) and *T. stenoptera* (Meyrick)) construct flattened elliptical silken cases, which are portable and have a slit in one end through which the larva partially emerges to feed.

Diagnosis. Wingspan 11-14 mm. Male has distinctive translucent hindwings with veins marked blackish (Fig. 26); both sexes diagnosed amongst NZ Oecophoridae (including *Tachystola acroxantha*) by very narrow orange-ochreous forewing with a distinct dark streak arising from the tornus and a dark spot on the fold at about 1/2 wing length; apical forewing fringe strongly tinged pinkish (as in *T. acroxantha*).

Remarks. Tachystola is endemic to Australia (Common 1997) and, until recently, *T. acroxantha*, which occurs as an adventive in the British Isles, NZ and South Africa, was apparently the only member of its genus to have become established outside its home country. From photographs on the Bug Guide website, the Californian moths tentatively identified as *T. hemisema* appear to lack the dark spot on the fold present in almost all NZ specimens.

DEPRESSARIIDAE

***Depressaria radiella* (Goeze, 1783)**

Parsnip webworm (Fig. 28)

Phalaena (*Tinea*) *radiella* Goeze, 1783. *Entomologische Beyträge zu des Ritter Linné zwolften ausgabe des Natursystems* **3**(4): 162.

Haemilis pastinacella Duponchel, 1838. In: Godart, J.-B., *Histoire Naturelle des Lépidoptères ou Papillons de France* **11**: 153, pl. 291, figs 4-5.

NZ records and distribution. First record: larvae on hogweed (*Heracleum sphondylium*), DN: Port Chalmers, late Jan 2004, collector unknown (Patrick 2004). Subsequently found to be widespread in the Dunedin suburbs of Wakari, Leith Valley, St Clair and Green Island and as far south as Brighton; larvae on *H. sphondylium* and *Pastinaca sativa*, many reared (Patrick 2004). By 2010, found north to the border with South Canterbury (SC), at Herbert, near Oamaru and in the Waitaki Valley (M.C. Stanley pers. comm. Jan 2017). No extensive monitoring since.

Overseas distribution. Native to Europe, where very widespread, including Canary Isles; introduced to North America, where widespread across Canada

from Nova Scotia to Vancouver and south through U.S.A. to Arizona (Harper *et al.* 2002).

Biology. Adults emerge in NZ from mid-February to mid-March (Patrick 2004); they overwinter as adults but not observed in spring in this country; however, Patrick (2004) found one in June hibernating among books in his Dunedin garage. Life history summarised in Britain by Harper *et al*. (2002), in the U.S.A. by Gorder and Mertins (1984) and in NZ by Patrick (2004). Eggs laid in spring on leaves and flower-stalks of host plants (Gorder and Mertins 1984), chiefly hogweed (*Heracleum sphondylium*) and wild parsnip (*Pastinaca sativa*). Larvae feed on flowers and developing seeds from very tough silken galleries lined with frass (Harper *et al*. 2002) and retreat into these when disturbed. Damage to flower-heads and seed-heads is often conspicuous. Fully grown larva leaves seed-head in summer and enters stem, where it usually chews a circular exit hole in the side and pupates among a few strands of silk; often several pupae in a single stem. Larva described as follows (adapted from Harper *et al*. 2002): head, thoracic legs and anal plate all black; prothoracic plate black with narrow median sulcus; body pale grey, ventral and spiracular areas dull yellow, pinacula conspicuously raised, shining black.

Diagnosis. Wingspan 24-29 mm (Harper *et al*. 2002). The longitudinal black streaking along the veins in the apical half of the forewing, crossed by a strongly angulated pale fascia at ¾ wing length, is distinctive in a NZ context. In life, pale brown thorax contrasts with much darker brown forewings (less so in pinned specimens, which can be greasy). The endemic depressariid *Phaeosaces apocrypta* Meyrick (formerly in Oecophoridae) is similar in size, wing shape and resting posture (wings held flat) and sometimes has a trace of dark longitudinal forewing streaking, but this is confined to the subterminal area; there are usually three dark stigmata in *P. apocrypta* (plical, first and second discal), lacking in *D. radiella*. The thorax in *P. apocrypta* is concolorous with the forewing.

Remarks. Patrick (2004) expressed concerns about any possible expansion in host plant range by this moth in NZ, given that endemic Apiaceae are important as host plants and nectar sources for native insects, especially species of speargrass (*Aciphylla*). However, the only host plants recorded in Europe apart from hogweed and wild parsnip are giant hogweed (*Heracleum mantegazzianum*) (Eilmus and Kurzawa 2015) and fool's watercress (*Apium nodiflorum*) (Harper *et al*. 2002), in spite of a great diversity of structurally similar Apiaceae there. Patrick (2004) recorded larvae feeding on giant hogweed in the Leith Valley DN in 2004.

In most of the recent literature on the parsnip webworm (including Harper *et al.* 2002, Patrick 2004, Zangerl *et al.* 2008, Jogesh *et al.* 2013), the scientific name is given as *Depressaria pastinacella* (Duponchel) but, prior to 1966, this species was known as *Depressaria heracliana* (Linnaeus). Karsholt *et al.*

(2006) have shown that the oldest available name for the parsnip webworm is *Depressaria radiella* (Goeze).

ELACHISTIDAE: PARAMETRIOTINAE

***Microcolona* sp. A**

(Fig. 29)

NZ records and distribution. First record: 1 ♂, AK: Parnell Rose Garden, 26 Sep 1989, J.S. Dugdale (NZAC). Subsequent records: AK: 25 specimens, Albert Park, by day, 2006-2010, S.E. Thorpe, NH (NZAC, NHNZ); 2 specimens, Scandrett Regional Park AK, by day, 6 Aug 2017, RJBH, J. Zhao (NZAC).

Overseas distribution. Unknown, but might originate from eastern Australia.

Biology. Adults by day, August to early January (no records in November). Life history unknown, but specimens from Albert Park were collected from the underside of lower leaves of the Australian giant spear-lily, *Doryanthes palmeri* (Doryanthaceae) (S.E. Thorpe pers. comm.; NH database) and one of the Scandrett specimens was at rest on a leaf of the native tank-lily, *Astelia hastata* (Asteliaceae). Related moth species and indeed many Parametriotinae have larvae that feed in seeds or fruits; however, the wide spread of adult records from late winter to summer is perhaps atypical of a fruit feeder.

Diagnosis. Wingspan 8.5-11 mm. Unmistakeable in a NZ context: forewing superficially black with the only distinct marking a bright yellow half-ellipse on the costa at ¾ wing length. Under magnification, bases of the black forewing scales are grey, so entire wing has finely mottled appearance; also raised black scale tufts below the fold at ¼ and ½ wing length (that at ¼ being much larger), a small scale tuft between these above the fold and another moderately large scale tuft near the dorsum at ¾; a small leaden spot beyond the scale tuft at ½ and larger leaden spot near apex.

Remarks. This distinctive species has not been found during searches in ANIC and BMNH; it is probably undescribed and might never have been collected outside NZ. However, its abundance in parks in the central city of Auckland, where exotic vegetation dominates, strongly suggests that it is an adventive species. The two Scandrett specimens were found among remnant native vegetation but the nearby homestead has a well-established garden of exotic plants. Although there was a gap of nearly 20 years between the first record of this species (in Parnell) and its subsequent rediscovery in Albert Park, it was probably simply overlooked during this period.

This species is assigned here to *Microcolona* Meyrick based largely on an examination of the male abdomen and genitalia. These conform to those of the endemic *M. limodes* Meyrick in possessing a pair of elongate coremata on the modified sternite 2, a group of spinose setae on the valva apex and two pairs of juxta lobes. They differ in the much longer and narrower phallus, the

longer and narrower valva and in the spine-like anterior process of the vinculum. In wing shape and conformation of the raised forewing scale tufts, *Microcolona* sp. A is very similar to *M. limodes*. *Microcolona*, as currently constituted, is a very widespread genus, with the majority of described species in Australia and India but a few also in Indonesia, Africa, South America and East Asia.

COSMOPTERIGIDAE

Cosmopterix attenuatella (Walker, 1864)

(Fig. 30)

Gelechia attenuatella Walker, 1864. *List of the specimens of lepidopterous insects in the collection of the British Museum* **XXX**: 1019.

NZ records and distribution. First record (NZ mainland): 4 ♂♂, ND: Kapowairua, Spirits Bay, 12, 13 Feb 2006, NH (NHNZ). Subsequent records: 1 specimen, ND: Te Paki (shearers' quarters), m.v. light, 2 Nov 2007, RJBH, S. Forgie (NZAC); 1 specimen, ND: Whakaruangangana gumland near Kaikohe, 3 Feb 2008, RJBH (NZAC). Recorded in AK from 2013 onwards (Kakamatua Inlet, Waitakere Ranges; Waharau Reg. Park, Hunua Ranges; Albany; Freemans Bay). One seen but not captured, Judea, Tauranga BP, early Feb 2014 (RJBH pers. obs.).

Overseas distribution. Nearly cosmopolitan in subtropical and tropical regions: U.S.A., Caribbean, Central and South America, Madeira, Canary Islands, Madagascar, Seychelles, Mauritius, Taiwan, Australia and the Pacific (Hodges 1978, Koster 2010). In the NZ region, previously known from the Kermadecs (Dugdale 1988: 235).

Biology. Adults in NZ in November and January to March; in the tropics year-round (Hodges 1978). Not yet reared in NZ but mines suspected to be of this species have been found by N. Martin in an introduced *Cyperus* sp. Recorded host plants overseas include *Cyperus rotundus* and *Scirpus* (Cyperaceae): the larva mines a leaf, starting near the tip and moving down; the mine occupies the whole leaf and contains black frass; the older part of the mine becomes brown and shrivelled, while the freshly mined part is pale yellow (Koster and Sinev 2003). Pupation inside the mine in a whitish elongated cocoon (Fletcher 1933, Koster and Sinev 2003).

Diagnosis. Wingspan 8-9 mm (NZ specimens). A very narrow-winged species, unlike any other moth currently known from NZ: forewing blackish, with broad bright orange fascia at 2/3 wing length bordered on each side by narrow shining metallic band; outer metallic band interrupted by streak of orange scales extending from the orange fascia. However, there are numerous similar species of *Cosmopterix* Hübner, so specimens caught in NZ should be examined carefully in case another member of the genus turns up.

Remarks. It will be interesting to see how far this essentially tropical and subtropical species spreads on the NZ mainland and whether its establishment proves to be permanent. There are numerous introduced *Cyperus* species in NZ, as well as two endemic species, *C. ustulatus* and *C. insularis*; the latter is a declining plant usually associated with sea-bird colonies and has not been searched for leaf mines. Nicholas Martin found very small mines in the tough leathery leaves of *C. ustulatus* at Omana Regional Park AK in June 2017 but rearing failed and identity of the miner as *Cosmopterix attenuatella* is unconfirmed.

BLASTOBASIDAE

***Blastobasis marmorosella* (Wollaston, 1858)**

(Fig. 31)

Oecophora marmorosella Wollaston, 1858. *Annals and Magazine of Natural History* (third series) **1**: 128.

Blastobasis sarcophaga Meyrick, 1902. *Transactions and Proceedings and Report of the Royal Society of South Australia* **26**: 169.

Blastobasis lignea of Edwards (1996: 100), *nec* Walsingham (1894: 550).

NZ records and distribution. First record: 1 ♂, AK: Auckland City, Princes St., 16 Nov 1988, NH (NHNZ). Subsequent records (all AK; all NHNZ unless otherwise stated): 1 ♀, same locality, 28 Nov 1988 (NZAC); 2 ♀♀, same locality, 12 Dec 1988 and 23 Oct 2012; 1 ♂, Auckland City, Symonds St, indoors, 3 Feb 1989; 1 ♀, same locality, freshly dead indoors, 10 Dec 2015; 1 ♀, Ponsonby, Mokau St, to light, 3 Jan 1990; 1 ♀, Freemans Bay, Wellington St, to light, 20 Mar 1994.

Overseas distribution. Madeira and nearby Porto Santo, Canary Islands, also mainland Europe (Portugal, Spain and France) (Karsholt and Sinev 2004). Perhaps originally endemic to Madeira, which has a large endemic radiation of *Blastobasis* Zeller (Karsholt and Sinev 2004). Introduced to Australia, where it was wrongly identified as *B. lignea* Walsingham (Edwards 1996: 100). (Karsholt and Sinev (2004) transferred *Blastobasis sarcophaga*, described from Australia by Meyrick (1902) from the synonymy of *B. lignea* to the synonymy of *B. marmorosella*.)

Biology. October to March in NZ. Karsholt and Sinev (2004) stated that the early stages were unknown, but Meyrick (1902) in the original description of *B. sarcophaga* mentioned a specimen given to him by George Masters that had been reared from ‘dried skins’ and there is one reared specimen in ANIC, bred by V.J. Robinson from ‘moth bodies’ from Wollongong, N.S.W. in November 1963.

Diagnosis. Wingspan 16-23 mm (Karsholt and Sinev 2004). *Blastobasis* sp. near *tarda* Meyrick (the only other blastobasid known in NZ) is a smaller species (wingspan 13-16 mm) with the dark spots around the forewing apex and along the termen indistinct (distinct in *B. marmorosella*). *Blastobasis* sp.

near *tarda* has a much narrower hindwing than *B. marmorosella*: at 3/4 hindwing length the hindwing is distinctly narrower than the forewing (about 1/2 the breadth in the male, 2/3 the breadth in the female) but, in *B. marmorosella*, the hindwing is nearly as broad as the forewing at this point (see Fig. 31). The male of *B*. sp. near *tarda* has distinctive, strongly thickened labial palpi, with the third segment blunt; the palpi in male *B. marmorosella* are narrow and the third segment is pointed.

Remarks. This species is elusive and known from rather few specimens in all of the localities where it has been found. Only 6 Australian specimens are present in ANIC, the last of these collected in 1974. Karsholt and Sinev (2004) listed only one recent specimen from Madeira and Porto Santo (where the species is almost certainly indigenous), collected by Karsholt in 1994. In NZ, only 8 specimens have been collected in the 19 years since it was first recorded. The moth has probably been overlooked.

Both of the Australian localities given by Karsholt and Sinev (2004) are misspelt: they should be Malua Bay (not 'Malus Bay') and Cronulla (not 'Cronulia'), N.S.W.

GELECHIIDAE: GELECHIINAE

***Symmetrischema striatella* (Murtfeldt, 1900)**

(Fig. 32)

Eucatoptus striatella Murtfeldt, 1900. *Canadian Entomologist* **32**: 163.

NZ records and distribution. First record: 1 ♀, AK, Freemans Bay, Hayden St, to Heath trap, 9-10 Apr 2006, NH (NHNZ). Subsequently 10 further specimens at the same locality, but none since 2010 (NH database, NHNZ); also 1 ♂, Glen Eden AK, u.v. trap, 14-15 Apr 2018 (NZAC). Three records outside Auckland: 1 ♂, WO: Bridal Veil Falls, m.v. light, 10 Dec 2006, RJBH, NH, G. Hall, A.W. Emmerson; 1 ♂, ND: Whangarei, Kamo, 20 Apr 2010, RJBH, G. Hall (Fig. 32); 1 ♀, ND: Mangawhai, 23-24 Mar 2018, RJBH (all NZAC).

Overseas distribution. U.S.A. including Hawaii, Central America (Mexico and Panama) and South America (Venezuela, Argentina and Chile) (Povolný 1994). 'Native' range not clearly established, might have spread in the U.S.A. with weedy *Solanum* species such as *S. nigrum* (*cf.* Keifer 1937) but considered native in California by Powell and Povolný (2001).

Biology. Adults in NZ from December to April. Murtfeldt (1900), in her original description, recorded the larvae as feeding in the berries of black nightshade (*Solanum nigrum*) in Missouri. However, Keifer (1937), as well as Powell and Povolný (2001), observed larvae making terminal leaf shelters on various *Solanum* spp, folding each leaf neatly and sealing the edges with silk, then skeletonising the leaf from within; frass is packed at one end of the shelter. Pupation is away from the shelter: Powell and Povolný (2001)

recorded a pupa in a dry *Brassica* stem. The larva is described as follows (summarised from Murtfeldt (1900), with terminology updated): 8 mm long, 2 mm in diameter, stout; head small, cordate, very dark shining brown; prothoracic plate concolorous with head; thoracic legs minute; prolegs short; body pale translucent greenish yellow, with five interrupted longitudinal crimson stripes; a broad, purplish subcutaneous spot on dorsum of A5. For a more detailed larval description including details of chaetotaxy and crochets, see Keifer (1937). Powell and Povolný (2001) listed the following host plants from coastal scrub and dunes in California: *Solanum americanum*, *S. furcatum*, *S. douglasii*, *S. xantii*, *S. wallacei* and *S. nigrum* (Solanaceae). Not yet reared in NZ, but *Solanum nigrum* occurs here as an introduced plant and the indigenous *Solanum nodiflorum* is very closely related to *S. americanum*, from which it was only recently separated (Manoko *et al*. 2007).

Diagnosis. Wingspan 12 mm. The striate forewing pattern with its irregular suffusion of blackish scales along the dorsum, combined with the three dark longitudinal lines on the thorax, is diagnostic in a NZ context. The male has a distinctive pencil of white hair scales arising from the hindwing costa and, if the pencil is spread, these can extend beyond the forewing costa in set specimens. The male genitalia and part of the female genitalia (ostium and segment 8) were illustrated by Povolný (1967).

Remarks. This species is unusual among adventive moths in NZ in having a New World origin; its congener, *Symmetrischema tangolias* (Gyen), another *Solanum*-feeder, is likewise American but has also been introduced to Australia and might have entered NZ via that country. *Symmetrischema striatella* is not known from Australia but might have been overlooked there: it seems elusive in NZ and has only been found in small numbers. Most NZ specimens have been taken in urban or suburban situations but one, from Bridal Veil Falls WO, was collected in native forest.

The original spelling of the species name *striatella* is retained here following *e.g.* Keifer (1937) and Hodges (1983) (Povolný (1967) amended it to *striatellum*).

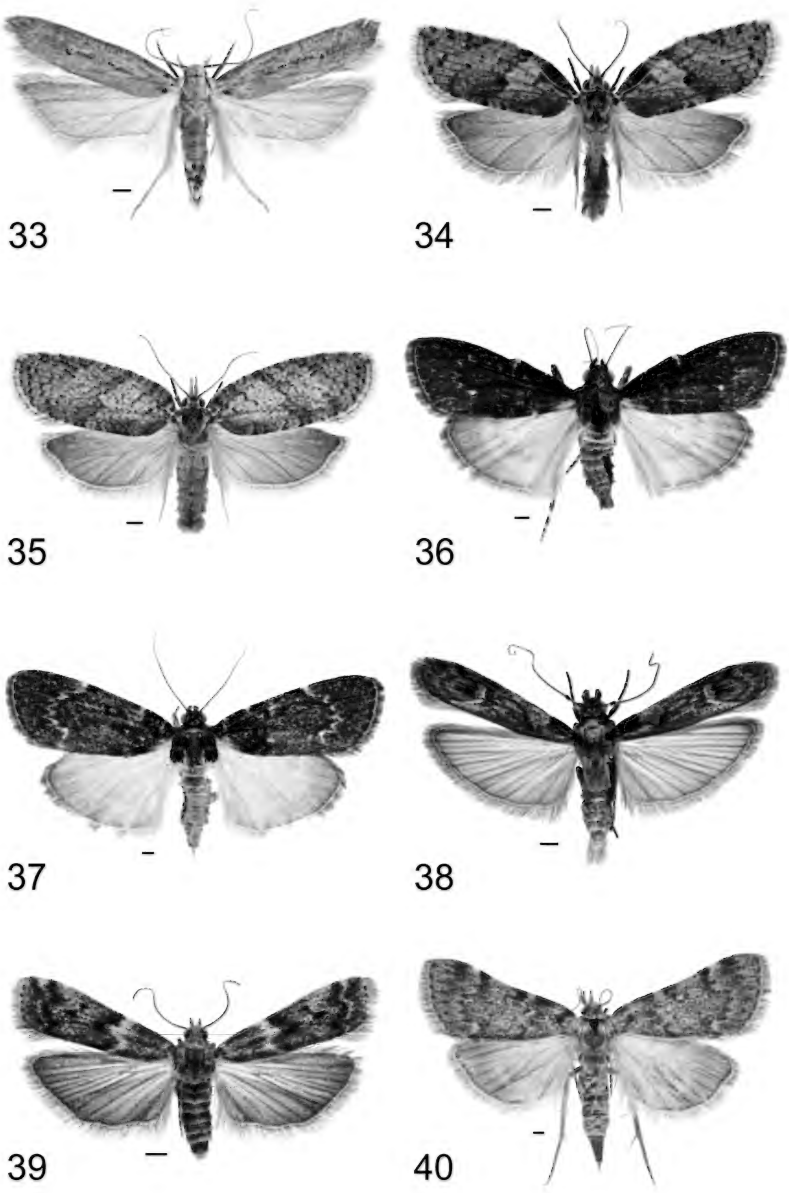
GELECHIIDAE: APATETRINAE

***Platyedra subcinerea* (Haworth, 1828)**

(Fig. 33)

Recurvaria subcinerea Haworth, 1828. *Lepidoptera Britannica* [Part IV]: 548.

NZ records and distribution. First record: 1 specimen, CO: Alexandra, 28 Sep 2010, B.H. Patrick (BPNZ). Another at the same locality, 29 Oct 2010. Subsequently singletons from Kaituna Valley MC, 25 Sep 2012; Birdlings Flat MC, 7 Aug 2014 (both BPNZ); and Dinton St, Russley, Christchurch MC, 7 Nov 2015, NH (NHNZ).



Figs 33-40. Gelechiidae, Tortricidae, Pyralidae: (33) *Platyedra subcinerea* ♂. (34-35) *Isotenes miserana*: (34) ♂; (35) ♀. (36-37) *Stericta carbonalis*: (36) ♂; (37) ♀. (38) *Balanomis encyclia* ♂. (39) *Ephestiopsis oenobarella* ♀. (40) *Aglossa pinguinalis* ♀. Scale bars 1 mm.

Overseas distribution. Europe to North Africa, Asia Minor and central Asia; introduced to North America, where established in New England for many years and in California since about 1990 (Bland *et al*. 2002, Powell and Opler 2009).

Biology. Adults in NZ at light from August to early November (presumably after overwintering: see below). Life history in NZ not recorded. In Britain, eggs laid on *Malva sylvestris* or *Alcea rosea* (garden hollyhock) (both Malvaceae) in spring; larva feeds in summer on flowers and seeds of the host plant (Bland *et al*. 2002). *Malva parviflora* is recorded as a host plant in California (Powell and Opler 2009); all these plants are present in NZ. Occupied seeds have the sepals sealed down to cover the seed completely (Bradford 1979, Bland *et al*. 2002). The larva is described as follows by Bland *et al*. (2002): 'Head and divided prothoracic plate black, but sometimes pale to dark brown ... body creamy white, each segment bearing a broad anterior and narrower posterior interrupted transverse ring of carmine pink.' Adults hatch in late summer (August in Britain) and overwinter in that stage.

Diagnosis. Wingspan 16-18 mm (Bland *et al*. 2002). Resembles endemic Apatetrinae of the genus *Anisoplaca* Meyrick, especially *A. achyrota* Meyrick. At a glance, *P. subcinerea* is narrower-winged than *A. achyrota*, with the forewing stigmata much less distinct and the hindwings paler. Diagnosed by the unmarked mesothorax and distinct black spot at the base of the forewing dorsum; this spot appears 'tucked' between the tegula and the mesothorax when the moth is at rest. *Anisoplaca achyrota* has a triangle of black spots at the rear of the mesothorax but no spot at the base of the forewing dorsum. The termen of the forewing and the fringe in *P. subcinerea* are plain brownish; in *A. achyrota*, the termen has a more or less interrupted dark line and the fringe is distinctly chequered.

Remarks. Platyedra subcinerea was first identified in NZ on the basis of the Christchurch specimen collected by NH in 2015; subsequently B.H. Patrick (pers. comm.) discovered several specimens, all collected earlier, in his collection (BPNZ). This is another species that has arrived in NZ from Europe or possibly North America, without having been detected in Australia. So far, the only records here are from overwintered adults captured at light in late winter and spring. It might well have been established for a number of years, as there is a wide spread of records. As potential host plants, there are 9 introduced species of *Malva* and 2 of *Alcea* naturalised in NZ, along with a number of other introduced Malvaceae.

TORTRICIDAE: TORTRICINAE

***Isotenes miserana* (Walker, 1863)**

(Figs 34-35)

Teras miserana Walker, 1863. *List of the specimens of lepidopterous insects in the collection of the British Museum* **XXVII**: 301.

NZ records and distribution. First record: 1 specimen, AK: Mt Albert, Bennett St, 21 Apr 2007, NH (NHNZ, on loan to PHEL). Subsequently larvae in fallen *Camellia* flowers and litter, Kitenui Ave., Mt Albert, July 2007, moths emg. August (NZAC). Now widespread and very common in Auckland, *e.g.* Albany (Redvale), Glen Eden, Henderson, New Lynn, Panmure, Red Beach, St. John's, and Northcote (Tuff Crater); also widespread in Northland (recorded from Russell and Mangawhai). Likely to have spread further by now.

Overseas distribution. Endemic to Australia; widespread along the east coast from Victoria to Queensland and also in the Northern Territory (Herbison-Evans and Crossley [1996-2017]).

Biology. Adults in NZ throughout the year. The female uses a corethrogyne of specialised scales near the abdominal tip to construct a fence of vertical scales around the egg-mass (Common 1990: 279 and fig. 51.15). Larvae usually feed between spun leaves of a very wide range of plants; hosts listed by Common (1990) for Australia include rose (*Rosa* spp), camellia (*Camellia* spp), lupin (*Lupinus* spp), lantana (*Lantana* spp), oleander (*Nerium oleander*), camphor laurel (*Cinnamomum camphora*), macadamia (*Macadamia*) and *Toona australis*. Larvae also bore into fruits of a number of plants, including several of economic importance, such as *Citrus* spp, peach (*Prunus persica*), apple (*Malus domesticus*) and mulberry (*Morus* sp.). In NZ, several reared from larvae in leaf litter and dead petals of *Camellia*; one from a guava fruit (*Psidium* sp.) and two from grapes (*Vitis vinifera*). Final instar larva (summarised from Dugdale *et al*. 2005): head evenly dark brown; prothoracic plate marginally dark brown; body creamy-pallid, with [faint] subdorsal stripe from T2 to A9; D pinacula on A1-8 paler than cuticle; anal shield with distinct brown border and with seta SD2 base a conspicuous pale spot (description probably from preserved material). Live larvae have the subdorsal line quite distinct, irregular and reddish brown; there is also a narrow dark dorsal line interrupted on each segment by a pair of transverse reddish brown bars. Dugdale *et al*. (2005) gave characters of chaetotaxy and keyed the larva out in a NZ context.

Diagnosis. Wingspan 14-23 mm. Size, wing shape and pattern not dissimilar to *Epiphyas postvittana* (light brown apple moth), but *E. postvittana* is always brown, never grey like *I. miserana*. The female corethrogyne, a pair of dense tufts of truncate pale yellowish scales at the abdominal apex, is characteristic. Male with distinctive modified tegula: the anterior part with normal grey scales, concolorous with thorax; posterior part a group of long narrow glossy beige scales that contrast with the thorax and forewing. Both sexes have the inner surface of each labial palpus clothed in snow-white scales and with at least some rust-red scaling on the forewing when seen under magnification.

Remarks. This species is considered a pest of economic importance (Dugdale *et al*. 2005) because of the larval damage to commercial fruit. So far in Auckland it has occurred mainly in suburban environments in the drier eastern suburbs but, in Henderson and Glen Eden, it has been found close to the extensive native forest of the Waitakere Ranges.

PYRALIDAE: EPIPASCHIINAE

***Stericta carbonalis* (Guenée, 1854)**

(Figs 36-37, 53)

Helia carbonalis Guenée, 1854. *Histoire Naturelle des Insectes: Species Général des Lépidoptères* vol. 9 part 8: 77.

NZ records and distribution. First record: 1 ♂, MC: Banks Peninsula, 160 Reynolds Valley Rd, to house light, 21 Dec 2009, S.V. Fowler. Subsequently common at this locality (S.V. Fowler pers. comm. 2017) as well as in the wider Christchurch and Banks Peninsula area (MC); localities include Irwell, Woolston, Birdling's Flat, Port Hills, Bossu Road, Decanter Bay and Diamond Harbour (B.H. Patrick pers. comm. 2017; BPNZ). Probably already more widespread but recording is less intensive outside MC.

Overseas distribution. Endemic to Australia: Queensland, New South Wales, A.C.T., Victoria and Tasmania (including Flinders Is.) (Common 1990, specimens in ANIC).

Biology. Adults in NZ from late December to early March. Attracted to light, but also often found indoors and congregating in confined spaces, *e.g*. a garden shed (J. Sullivan per Naturewatch NZ) and a horse float: congregations often mostly or all of male moths. S.V. Fowler (pers. comm.) suggests the smell of burnt gum-wood from a log fire attracted moths into his house; the black coloration is suggestive of an association with burned areas of vegetation in the wild. Larvae feed on dead leaves of *Eucalyptus*, *e.g*. dead leaves in a hollow trunk of *E. macrorrhyncha* and on a fallen branch of *E. pauciflora* (reared specimens in ANIC). Reared in NZ from the egg and part way through its larval stages by S.V. Fowler. Eggs laid in captivity between layers of tissue paper; paper around the eggs stained brown by a secretion of unknown purpose from the female. Early instar larvae fed on fallen 'gum nuts', later taking to the fallen leaves. The larva (instar unknown) is figured here for the first time from a photograph by S.V. Fowler (Fig. 53): it is very dark brownish grey, with a shining dark chestnut-coloured head, blackish brown prothoracic and anal plates and glossy greyish pinacula. Pupation not yet observed.

Diagnosis. Wingspan 25-32 mm. Black forewings, finely sprinkled white, with pale, curved, dentate postmedian line, combined with upturned labial palpi, are diagnostic in a NZ context. Male head distinctively 'crested', due to a pair of densely scaled processes arising from the scape of each antenna;

also with a protrusion / thickening of the forewing costa just before 1/2 wing length, which is marked with a short transverse line of pale orange scales and associated with an elongate subcostal 'pocket' on the underside of the wing.

Remarks. Stericta carbonalis is unusual among adventive species in NZ in that it was first recorded in the South Island and remains unknown from the North Island. It might have been accidentally imported via the container terminal at Lyttelton. This is the only species of Epipaschiinae recorded from NZ; Shaffer *et al*. (1996) listed 79 named species in 20 genera in Australia and suggested that many more species await description there. The functions of the male antennal and forewing modifications have apparently not been elucidated.

PYRALIDAE: PHYCITINAE

***Balanomis encyclia* Meyrick, 1887**

(Fig. 38)

Balanomis encyclia Meyrick, 1887. *Transactions of the Entomological Society of London* **1887**: 265.

NZ records and distribution. First record: 1 ♀, AK: Waitakere Ranges, Spragg's Bush, 9 Mar 1984, J.S. Dugdale and C.J. Green (NZAC). Subsequently only from Aupouri Peninsula, far northern Northland (ND): 3, Houhora and Henderson Bay, 2004 (NHNZ); 2, Spirits Bay, 16 Feb 2006 (NHNZ); 1 ♂, North Cape, emg. 3 Jan 2008 ex larva 19 Dec 2007 (NZAC) (see Biology); 4, Spirits Bay, late March 2018 (EENZ).

Overseas distribution. Endemic to Australia: New South Wales, Queensland and Western Australia (specimens in ANIC).

Biology. Adults in NZ from December to early March. The North Cape larva was beaten from the climber *Cassytha paniculata* (Lauraceae) growing on pohutukawa (*Metrosideros excelsa*); it fed from a light silken web on *Cassytha*, pupating in the web. This is possibly the only rearing record; none of the ANIC specimens was reared. This plant is regarded as native to NZ, but also occurs in Australia.

Diagnosis. Wingspan 18-19.5 mm. Forewing pattern diagnostic, with prominent pale crescent in the disc at 2/3 that is white basally and yellow-ochreous distally, white scaling produced as a line towards tornus; both sexes with pinkish scaling centrally on T1 and T2 of abdomen. Male with diagnostic secondary sexual characters: notch near base of antennal flagellum followed distally by narrow glossy black scales; fold at base of forewing costa, surrounded by black scales and containing a pencil of hair-like pale scales; beyond this, large triangular subcostal scale tuft, directed towards the wing dorsum, containing pinkish, yellow-ochreous and black scales.

Remarks. This species might have been present in NZ for some time. The only known host plant, *Cassytha paniculata*, is confined in NZ to the far north, occurring commonly from North Cape south to Kaitaia and Mangonui: this is a poorly collected part of the country for Lepidoptera and *Balanomis encyclia* is clearly established here. The Auckland record, on the other hand, is likely to be the result of migration from Australia.

***Ephestiopsis oenobarella* (Meyrick, 1879)**

(Fig. 39)

Myelois oenobarella Meyrick, 1879. *Proceedings of the Linnean Society of New South Wales* **4**: 228-229.

NZ records and distribution. First record: 1 specimen (lacking abdomen, probably female), HB: Haumoana, 20 Nov 1966, T.H. Davies (NZAC). Second record: Aroha Island, Kerikeri ND, 30 Apr 1983, C.J. Green (NZAC). Now widespread in Northland (Te Paki, Houhora, Karikari Peninsula, Trounson Kauri Park, Mangawhai) and Auckland (Redvale (Albany), Muriwai Beach, Glen Eden, Kelston, Freemans Bay, Manurewa (Murphy's Bush), Mt Wellington and Pollen Island). Also from Waikato (WO): 1, Port Waikato, Heath trap, 16-17 Apr 2006 and 1, Karewa Beach, Kawhia, 20 Apr 1987 (both NHNZ).

Overseas distribution. Endemic to Australia: Queensland, New South Wales and A.C.T. (records in ANIC); 1 specimen in ANIC from Western Australia (Harvey R., 14 km SW of Waroona).

Biology. Adults at light in NZ from early November to late April, usually in relatively open and/or modified habitats. Life history unknown.

Diagnosis. Wingspan 13-16 mm. Recognised amongst NZ phycitines by the numerous reddish pink scales on the thorax and forewing and by the pale, roughly Z-shaped, antemedian fascia, which is sharply bent outward on the fold. Both *Cadra cautella* (Walker) and *Ephestia elutella* (Hübner) can have some light pinkish scaling, but this is confined to the dorsal half of the forewing; in both species the antemedian line is nearly straight, not Z-shaped. *Ephestiopsis oenobarella* has distinctive 'ragged' tegulae, edged posteriorly with irregularly protruding blackish scales; *Cadra cautella* and *Ephestia elutella* have smoothly rounded tegulae lacking blackish scales.

Remarks. This species has probably been established in NZ for over 50 years, but has been overlooked or misidentified until recently. Almost all known NZ specimens are females; only a single male has been captured, at Freemans Bay AK on 17-18 Jan 2008 (NHNZ). Perhaps the female comes more readily to light than the male, as in some other pyralids, *e.g. Galleria mellonella* (Linnaeus). *Ephestiopsis oenobarella* is a poorly known species (both in NZ and Australia) and elucidation of its life history would be of interest.

PYRALIDAE: PYRALINAE

***Aglossa pinguinalis* (Linnaeus, 1758)**

(Fig. 40)

Pyralis pinguinalis Linnaeus, 1758. *Systema Naturae per regna tria naturae*: 533.

NZ records and distribution. First record: 1 ♂, NN: Nelson, 29 Dec 1955, E.S. Gourlay (NZAC). Also 7 reared by Gourlay in Dec 1965 from larvae in sheep manure collected by D.T. Munro at 41 Murphy St, Nelson (NZAC). No further records except: 2, Atawhai, Nelson NN, indoors, 12 and 20 Jan 2009, J.S. Dugdale (NZAC).

Overseas distribution. Native to Eurasia; introduced some time before 1990 to the U.S.A. Also introduced to Australia (Tillyard 1926).

Biology. Adults in NZ in December and January. Larvae only recorded in sheep dung in NZ but in Europe also on refuse of cereals, dried seeds, grass husks and other vegetable detritus (Beirne 1952, Goater 1986). Larva in a greyish silken tube covered externally with detritus, described as 'black or blackish brown' (Beirne 1952); photographs on the Lepiforum website (*www.lepiforum.de*) show that the full grown larva is blackish and glossy, while the first instar is translucent whitish with a pale brown head and prothoracic plate. Larvae often live for two years (Goater 1986). The moth is usually found indoors, frequently in outhouses or barns (Goater 1986); it does not often come to light.

Diagnosis. Wingspan 24-39 mm. *Aglossa caprealis* (Hübner), the only other member of the genus in NZ, is smaller than *A. pinguinalis* (wingspan up to 27 mm), with a much paler hindwing (whitish, as opposed to greyish in *A. pinguinalis*); forewing with irregular patch of yellowish scales in the disc just beyond 1/2 (no such patch in *A. pinguinalis*). The scape of the antenna is yellowish is *A. caprealis*, dull brownish in *A. pinguinalis*.

Remarks. Although E.S. Gourlay's specimens of *A. pinguinalis* from the 1950s and 1960s were correctly identified in NZAC, its presence in NZ does not appear to have been recorded until now. It is an elusive species (Goater 1986) and might well be commoner in this country than the few records suggest; lepidopterists seldom investigate barns and dung.

CRAMBIDAE: MUSOTIMINAE

***Musotima ochropteralis* (Guenée, 1854)**

(Fig. 41)

Isopteryx ochropteralis Guenée, 1854. *Histoire Naturelle des Insectes: Species Général des Lépidoptères* vol. 9 part 8: 230.

NZ records and distribution. First record: 1 ♂, AK: Mt Albert Research Centre, light trap, 14 Jan 1981, C.J. Green (NZAC). Also 2, same locality, 1982 and 1984; and singletons in Henderson, Mt Albert, Grey Lynn and

Devonport AK 1984-1989, Mairangi Bay AK, 2002 and 2003, Royal Oak AK, 2004 and Freemans Bay AK, 2015 (NZAC, NHNZ). A large population (larvae and adults) discovered in a garden in Katikati BP in 2016 among *Adiantum capillus-veneris*; larvae then found on this fern at Devonport AK by N.A. Martin and moths reared (NZAC).

Overseas distribution. Endemic to Australia: Queensland, New South Wales, A.C.T., Tasmania and Western Australia (ANIC).

Biology. Adults in NZ September to February, May and June: disturbed by day from *Adiantum* ferns and occasionally at light. Larvae in NZ on introduced maidenhair ferns *Adiantum capillus-veneris* and *A. raddianum* in suburban situations; in Australia recorded from *Adiantum aethiopicum* (Common 1990). Larvae graze the underside of the fronds, causing transparent windows and eventually skeletonising them. Full-grown larva bright apple-green, with glossy glass-like appearance (as in other Musotiminae); setae brown with black setal bases / pinacula; head paler yellowish green, speckled pale brown posteriorly, with black lateral stripe through stemmata and black setal bases; prothorax streaked and spotted black (from larva on *Adiantum raddianum*, Torpedo Bay, Devonport, 8 Feb 2017). Pupation in a loose silken web among the fronds.

Diagnosis. Wingspan: 12-14 mm. *Musotima nitidalis* (Walker) differs in having a large, white, more or less comma-shaped mark next to the forewing postmedian line at 2/3 (no such mark in *M. ochropteralis*) and 2 discrete white discal spots at 1/2 forewing length (where *M. ochropteralis* has a single comma-shaped spot). Hindwing distinctly marked in *M. ochropteralis*, with clear white postmedian and subterminal lines on a golden-brown ground; *M. nitidalis* has hindwing much paler than forewing and with indistinct cross-lines.

Remarks. This moth seems to be confined in NZ to warm, relative dry microhabitats in suburban situations (gardens and walls), usually near the coast. As with *Musotima nitidalis*, larvae are very prone to parasitism by the abundant introduced braconid wasp *Meteorus pulchricornis* (Wesmael): the parasitoid larva can be observed through the translucent cuticle of its host.

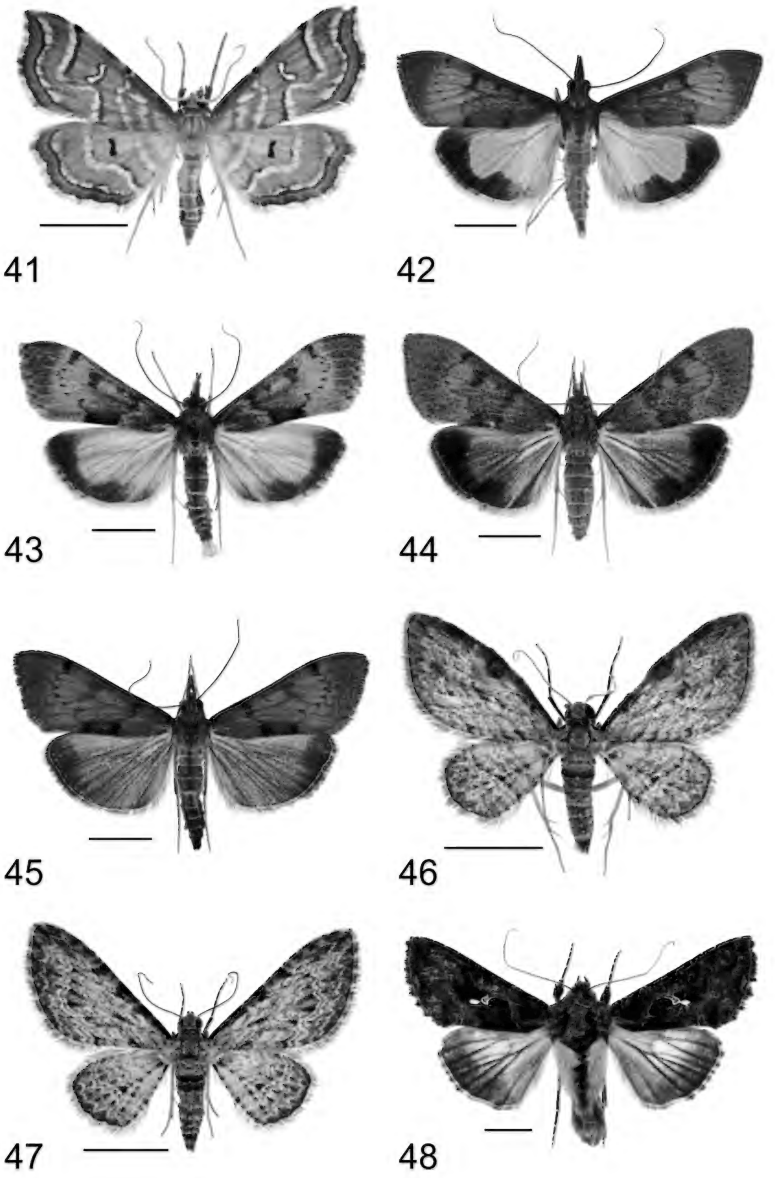
CRAMBIDAE: PYRAUSTINAE

***Uresiphita ornithopteralis* (Guenée, 1854)**

(Fig. 42)

Mecyna ornithopteralis Guenée, 1854. *Histoire Naturelle des Insectes: Species Général des Lépidoptères* vol. 9 part 8: 411.

NZ records and distribution. First record: 2 ♂♂, ND: Kaeo, 16 Jan 1921 (AMNZ) (apparently true *U. ornithopteralis* with no *U. maorialis* characters (see below)). A badly damaged specimen, Waitangi, Bay of Islands, ND, 14 Mar 1949, K.P. Lamb (NZAC) also apparently true *U. ornithopteralis*.



Figs 41-48. Crambidae, Geometridae, Noctuidae: (41) *Musotima ochropteralis* ♂. (42) *Uresiphita ornithopteralis* ♂. (43-44) *U. ornithopteralis* / *maorialis* (hybrids?): (43) ♂; (44) ♀. 45. *Uresiphita maorialis* ♂. (46-47) *Sigilliclystis insigillata*: (46) ♂; (47) ♀. (48) *Ctenoplusia limbirena* ♂. Scale bars 5 mm.

Possibly all other specimens under this name in NZ collections are the result of hybridisation between *U. ornithopteralis* and *U. maorialis* (C. Felder, R. Felder & Rogenhofer) (see below). Subsequent specimens with the hindwing underside character of *U. ornithopteralis* (see Diagnosis below) are from ND: Kerikeri Inlet (reared ex larvae on gorse (*Ulex europaeus*)); Uretiti Beach; Rangiputa Reserve, Karikari Peninsula; AK: Mt Albert; Cutty Grass Track, Waitakere Ranges (all NZAC).

Overseas distribution. Endemic to Australia, where recorded from all states and territories (specimens in ANIC and NZAC).

Biology. Larvae oligophagous on Fabaceae and occasionally Mimosaceae, but with a broad host range. Common (1990) listed *Hovea*, *Templetonia*, *Viminaria*, *Lupinus*, *Cytisus prolifera*, *Spartium junceum*, *Genista*, *Sophora microphylla* (NZ kōwhai) (all Fabaceae) and *Acacia* (Mimosaceae) as host-plants in Australia. In NZ specimens with *U. ornithopteralis* characters (see Diagnosis below) have been reared from gorse (*Ulex europaeus*). Larvae feed from silk spinnings on the foliage of the host plant. The larva closely resembles that of the endemic *Uresiphita maorialis*; in both taxa, the larva is green, with the prothorax black with three longitudinal white stripes; there is a yellow and white lateral line and the dorsal pinacula are black and raised, with conspicuous white spots surrounding the bases of the setae; prolegs greenish (*cf.* Hudson 1928: 180).

Diagnosis. Wingspan 25-36 mm. Only likely to be confused in NZ with its very close relative *Uresiphita maorialis* (see under Remarks below for taxonomy); but almost all NZ specimens with wing-pattern characters of *U. ornithopteralis* also show some characters of *U. maorialis* and there might be no 'pure' population of *U. ornithopteralis* here (*cf.* Holloway 1977, discussing *Uresiphita* Hübner on Norfolk Island). The following account supersedes that of Hoare (2011), who treated the taxa as subspecies (*Uresiphita polygonalis ornithopteralis* and *U. p. maorialis*) and who almost certainly underestimated the degree of introgression of characters where the two taxa meet. The most consistent diagnostic character is the distinct blackish terminal band on the underside of the hindwing in *U. ornithopteralis*; in *U. maorialis* there is no band but there can be some blackish scaling near the hindwing underside apex. *Uresiphita ornithopteralis* has the hindwing upperside rather bright clear yellow-orange (Fig. 42); in *U. maorialis* the hindwing is usually suffused greyish brown without any distinct orange colour (Fig. 45). Few specimens have the bright orange hindwing depicted and described by Hudson (1928: 180 and pl. XXI fig. 25), and these have a more or less pronounced suffusion of blackish scales between the veins in the anal 1/3 of the hindwing, creating a series of alternating blackish and orange streaks, as shown in Hudson's figure; in true *U. ornithopteralis* the wing never has a streaked appearance. In NZ, most specimens with the *U. ornithopteralis* character of a distinct blackish band on

the hindwing underside have the hindwing upperside more or less as in *U. maorialis* (either suffused brownish or orange with anal 1/3 streaked blackish) (Fig. 44).

Remarks. The Australasian members of the genus *Uresiphita* are in need of revision: currently three species are recognised: *U. maorialis* from NZ, *U. ornithopteralis* from Australia and *U. insulicola* (Turner) from Lord Howe Island. Species-level status for these taxa follows *e.g.* Shaffer *et al*. (1996), Holloway (1977) and Nuss *et al*. (2003-2016) but, in preliminary dissections of NZ males showing different hindwing characters as discussed above, no significant differences in male genitalia have been observed. The apparent hybridisation of *U. ornithopteralis* and *U. maorialis* in NZ suggests that full species status may not be appropriate for these two taxa. Relationships with the Palaearctic *U. gilvata* (Fabricius) (= *U. polygonalis* of authors) also need to be reassessed.

GEOMETRIDAE: LARENTIINAE

***Sigilliclystis insigillata* (Walker, 1862)**

(Figs 46-47)

Eupithecia insigillata Walker, 1862. *List of the specimens of lepidopterous insects in the collection of the British Museum* **XXIV**: 1245.

NZ records and distribution. First record: 1 ♀, AK: Freemans Bay, 7 Mar 2003, to light, NH (NHNZ). Subsequently, 12 specimens, same locality (11 in NHNZ, 1 in NZAC); also AK: 1 ♂, Omahu Rd, Remuera, 11 Sep 2005 (NHNZ); 2 ♀♀, 1 ♂, Redvale, Albany AK, 18 Apr 2010, 12 Apr 2012, 10 Mar 2016 (NZAC); ND: 1, Houhora, 18 May 2004, NH (NHNZ); NN: 1 ♂, Atawhai, Nelson, 5 Mar 2013, J.S. Dugdale (NZAC).

Overseas distribution. Endemic to Australia: Queensland, New South Wales, South Australia and Western Australia (ANIC); also recorded on Norfolk Island (Holloway 1977). Rather poorly represented in collections.

Biology. Adults in NZ in every month of the year except November, most frequent March and April. All specimens taken at light; females more often found than males (NH database). Life history unknown.

Diagnosis. Wingspan: 14-16 mm. Male unmistakeable in a NZ context because of the secondary sexual modifications of the forewing: a conspicuous ‘pocket’ on the upperside adjacent to costa at 1/2, bordered by long hair-like ochreous scales; within the pocket and almost concealed by these scales is a small group of blackish upright scales (presumably scent-scales); the pocket appears on the underside as a conspicuous raised blackish spot; another less conspicuous, elongate pocket on the forewing upperside associated with veins M1-M3 beyond the discal cell containing group of minute appressed ochreous scent-scales apically. Both sexes distinguished from other NZ Eupitheciini by the strongly reduced labial palpi, hardly visible in dorsal

view; superficially similar species such as *Pasiphila humilis* (Philpott) have conspicuous porrect labial palpi.

Remarks. The species present in NZ is identified as the Australian *S. insigillata* and not the closely related New Caledonian *S. lunifera* (Holloway), based on the wing pattern characters given by Holloway (1979: 300-301), in particular the lack of distinct crenulations in the postmedian line of the forewing and the barely sigmoidal postmedian line of the hindwing. The species is possibly established in this country at low density based on its fairly regular appearance in light traps since its first occurrence, although Holloway (1977, 1979) regarded it as a vagrant to Norfolk Island.

NOCTUIDAE: PLUSIINAE

***Ctenoplusia limbirena* (Guenée, 1852)**

(Fig. 48)

Plusia limbirena Guenée, 1852. *Histoire Naturelle des Insectes: Species Général des Lépidoptères* vol. 9 part 6: 350.

NZ records and distribution. First NZ record: 1 photographed, ND: Maungakaramea near Whangarei, 12 May 2011, O. Ball. First NZ specimen, AK: Freemans Bay, to light, 20-21 May 2011, NH (NHNZ). From 2012 onwards, common in the Auckland district; also present in the Coromandel district (1 dead in a spider's web, Waihi Motor Camp, 23 Mar 2012, NH). Its further spread south has not been well documented but now present in Taranaki (photographed by P. Bendle pers. comm.) and north-west Nelson (specimen in BPNZ).

Overseas distribution. Widespread from Canary Islands and southern Europe (migrant to northern Europe), across Africa to southern and south-east Asia as far east as New Guinea and Timor (Goater *et al*. 2003; Behounek *et al*. 2010). Recently recorded from Australia (Queensland) (E.D. Edwards pers. comm. 2016).

Biology. Adults at light in NZ in most months of the year. They also fly actively at dawn and in the evening towards dusk, visiting garden flowers and herbs such as *Origanum majorana* (pers. obs.; NH database). Larvae polyphagous on herbaceous plants; overseas recorded feeding on, *e.g*. *Agave*, *Althaea*, *Geranium*, *Lactuca*, *Mentha*, *Nicotiana*, *Primula*, *Salvia* and *Solanum* as well as various Fabaceae; in East Africa, also on *Pinus radiata* (Sevastopulo 1976, Goater *et al*. 2003). In NZ, only reared once so far, from larvae on garden parsley (*Petroselinum crispum*), by N.A. Martin (specimen in NZAC). Larva bright green, with three irregular white dorsal lines on each side, a white lateral line, white pinacula and green thoracic legs and prolegs; head green, in later instars usually with distinct black lateral line. White lines become indistinct in prepupal larva. Pupa in a thin cocoon of white silk. Excellent images of the life history are on the website of W. Wagner (*www.pyrgus.de/Ctenoplusia_limbirena_en.html*).

Diagnosis. Wingspan 30-33.5 mm (See Remarks below). Could be confused in NZ with *Chrysodeixis eriosoma* (Doubleday): latter is a larger moth (wingspan 35 mm or more), with pair of large mesothoracic crests, coppery brown at the base and pinkish at the tips; the mesothoracic crests in *Ctenoplusia limbirena* are smaller and blackish, scales indistinctly tipped white. Also, *C. limbirena* has elongate brown marking *ca* ½ way along termen, consisting of pinkish grey scales surrounded by coppery brown scales; no such marking in *C. eriosoma*. Male *C. eriosoma* has a large black anal tuft; *C. limbirena* lacks a conspicuous anal tuft.

Remarks. Goater *et al*. (2003: 179) gave the wingspan of *C. limbirena* as 34-39 mm in Europe; the NZ population is consistently smaller in size, up to 33.5 mm. Although *Ctenoplusia limbirena* was first recorded in Australia in 2013, it is possible that it had been overlooked in earlier years and that the NZ population (first recorded 2011) is the result of migration from Australia. The species has increased rapidly in NZ and is encountered frequently in native forest as well as suburban gardens.

NOCTUIDAE: NOCTUINAE

***Proteuxoa sanguinipuncta* (Guenée, 1852)**

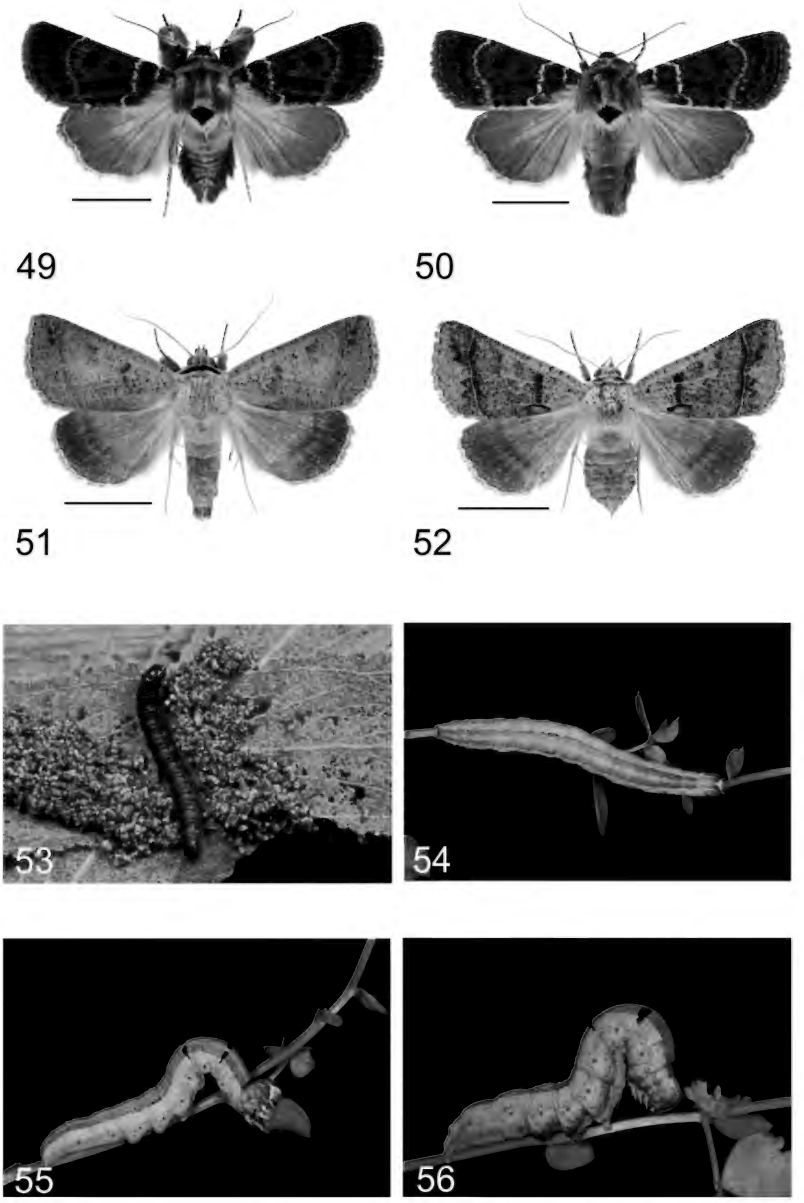
(Figs 49-50)

Amphipyra sanguinipuncta Guenée, 1852. *Histoire Naturelle des Insectes: Spécies général des Lépidoptères* vol. 9 part 6: 412-413.

NZ records and distribution. First NZ record: two ♂♂, HB: Blowhard Bush, m.v. light, 20 Feb 2007, RJBH (NZAC). Also GB: Lake Waikaremoana, 22 Feb 2007; TO: Waipapa Scenic Reserve, 23 Feb 2007, probably indicating it was already established in NZ. Has become increasingly common and widespread in the North Island with records from Northland to Wellington; recently colonised the northern South Island (Nelson and Marlborough Sounds), where larvae were found abundantly in places in August 2016 (R. Powlesland pers. comm.) (Hoare 2017).

*Overseas distribution***.** Endemic to Australia, where common and widespread: New South Wales, A.C.T., South Australia, Tasmania and Western Australia (specimen records in ANIC). In Australia, found at altitudes up to 1750 m (Mt Gingera, A.C.T.).

Biology. Adults in NZ from late January to early April; comes readily to light. In Australia, larvae feed on various unspecified grasses (Poaceae) (Common 1990, Herbison-Evans and Crossley [1996-2017]). Larva brown, with broad longitudinal blackish stripes either side of the dorsal midline (darker towards the front of each segment) and an oblique white line interrupting this stripe on each side of A7; paler brown sublaterally (from photograph by M. Crossley and description by Herbison-Evans and Crossley [1996-2017]). Not yet reared in NZ but larvae observed in pasture.



Figs 49-56. Noctuidae, Erebidae (adults); Pyralidae, Erebidae (larvae): (49-50) *Proteuxoa sanguinipuncta*: (49) ♂; (50) ♀. (51-52) *Pantydia sparsa*: (51) ♂; (52) ♀. Scale bars 10 mm. (53) *Stericta carbonalis* larva. (54-56) *Pantydia sparsa* larvae.

Diagnosis. Wingspan 39-44 mm. A moderately large, very dark noctuid, unlikely to be confused with any other in NZ; the small crimson spots on the forewing on their own are diagnostic, as is the dense fluffy scaling of the male foretibia in fresh specimens.

Remarks. This species was listed for NZ by Hoare (2010a) without further details; a full description together with figures of adults and genitalia is given by Hoare (2017). The placement of *Proteuxoa* Hampson in the subfamily Noctuinae follows Hoare (2017). It will be interesting to see how far *P. sanguinipuncta* spreads in NZ. Humid winter conditions seem unfavourable to the species: in a colony in the Motueka Valley observed in 2016, most larvae succumbed to a fungal infection, climbed to the tips of grass stems and died (J.S. Dugdale pers. comm.).

EREBIDAE: EREBINAE

***Pantydia sparsa* Guenée, 1852**

(Figs 51-52, 54-56)

Pantydia sparsa Guenée, 1852. *Histoire Naturelle des Insectes: Spécies général des Lépidoptères* vol. 9 part 6: 437.

NZ records and distribution. First NZ record: 1 ♂, ND: Houhora 14 Feb 2004, NH (NHNZ). Also 2, ND: Henderson Bay, Dec 2004 (NHNZ), indicating establishment; subsequently recorded widely in Northland in 2006-2007 (Te Paki (Spirits Bay Rd), Herekino Forest, Karikari Peninsula, Trounson Kauri Park (NZAC)). First AK record: Tiritiri Matangi Island, 28 Oct 2006 (NHNZ), thereafter common in the Auckland district. Now widespread on the Coromandel Peninsula CL (specimens in NZAC).

Overseas distribution. Probably endemic to Australia, where widespread almost throughout the country (Common 1990, specimen records in ANIC); also New Caledonia and Norfolk Island where the few records up to the late 1970s suggest that it might have been a vagrant (Holloway 1977, 1979); its current status on these islands is not known.

Biology. Adults at light in northern NZ in all months of the year. Common (1990) noted larvae in Australia on *Dillwynia ericifolia* and lucerne (*Medicago sativa*) (both Fabaceae), also on *Exocarpos aphyllus* (Santalaceae). The larva has not been found in the wild in NZ but a series was reared through from ova laid by a female taken at light at Albany AK on 29 Mar 2015. The larva is described and illustrated here for the first time.

First instar larvae active loopers, hanging from silk threads from the lid of the container when not actively wandering. Initially fed on white clover (*Trifolium repens*), on which young larvae grazed the leaves, later on *Lotus pedunculatus*, larvae seeming to prefer softer leaves from plants growing up among long grass. Final instar larvae (Figs 54-56) described from life on 10 May 2015 as follows: Length 48 mm. Body rather spindle-shaped, tapering

noticeably at T1 and T2 and slightly at A9-10 (head distinctly higher than T1, but hardly broader). Head mid-brown, mottled pale brown; frons and adfrontal areas cream, an irregular cream lateral line from above stemmata to rear of head, a short line on each side of vertex extending forwards to level of seta P1 or beyond and incorporating P2, this line continuous with subdorsal line of prothorax. Thorax and abdomen pale ochreous, pinkish-tinged at segmental joints; double dorsal line mottled darker brown, with some more or less indistinct black bordering on each side below on A4-6, narrowly bordered white below this, white border broadening into distinct cream stripe on prothorax (continuous with posterior head stripe, as above); laterally a more or less indistinct pattern of irregular fine pinkish, brown and whitish marbled stripes. D setae (under magnification) on A1-7 narrowly bordered blackish above and white below, borders forming more or less circular markings; D2 on A8 with more distinct pure black crescent caudally. Intersegmental membrane dorsally between A1 and A2 and between A2 and A3 with paired black markings (narrowly separated medially), visible when larva loops and exposed (more readily in younger larvae) as startle response when larva disturbed (Fig. 56). Prolegs on A3 absent, on A4 small, A5-6 well-developed; base of A5-6 prolegs pinkish, transversely mottled brownish, with white above each seta; apical half of proleg above planta greyish translucent with central lateral blackish spot bordered by dark crescent on each side. Anal prolegs each with two broken mottled brown longitudinal lines, outer line more distinct. Pupation in a cocoon among moss provided for this purpose; moths emerged 21 June to 15 July (specimens in NZAC).

Diagnosis. Wingspan 35-41 mm. Unmistakeable in a NZ context; the greyish forewing with its fine, pale, nearly straight postmedian line is characteristic, as is the large anterior thoracic crest, all but the apex of which is taken up by a blackish triangular mark.

Remarks. Pantydia sparsa has rapidly become one of the commonest noctuoid moths in northern NZ. It was added to the NZ list by Hoare (2010a), without further details; Hoare (2011) briefly discussed and illustrated the species. The adult habitus and male genitalia of *Pantydia* Guenée species somewhat resemble those of the Palaearctic and African genus *Lygephila* Billberg (Toxocampinae); however, the phylogenetic study of Zahiri *et al.* (2012) indicated that *Pantydia* in fact belongs to the subfamily Erebinae (tribe Euclidiini). Indeed, the conformation of the larval prolegs (absent on A3, reduced on A4) matches that of the European *Euclidia glyphica* (Linnaeus) (see the larval photographs at *http://www.lepiforum.de/lepiwiki.pl? Euclidia_Glyphica*) and not that of *Lygephila* (where A3 prolegs are present).

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APPENDIX 1

Collection data for figured specimens

Figs 1-8.

1. *Oinophila v-flava*. ♂, HB: Napier, Kennedy Park, emg. 31 Oct 2001, *Eucalyptus* bark and litter (NZAC). 2. *Erechthias capnitis*. ♂, Heron Park, Avondale AK, emg. 20 Sep 2001, from *Uromycladium* rust-gall on *Acacia mearnsii* (NZAC). 3. *E. capnitis*. ♂, Minnehaha Ave, Titirangi AK, lit window, 3 Oct 2001 (NZAC). 4. *E. capnitis*. ♀, Mile Bush Rd, Pukekawa WO, on tree at night, 18 Jan 2009 (NZAC). 5. *E. capnitis*. ♀, Preston Ave, Henderson, emg. 16 Dec 2002, from old galls on *Ardisia crispa* (NZAC). 6. *Parochmastis hilderi*. ♀, Hayden St, Freemans Bay AK, indoors, 23 Jul 2015 (NZAC). 7. *Monopis* sp. near *icterogastra*. ♂, Hayden St, Freemans Bay AK, Heath trap, 3-4 Feb 2016 (NHNZ). 8. *Oenoe* sp. A. ♀, Rimutaka Pl., Titirangi AK, m.v. light, 15 Mar 1999 (NZAC).

Figs 9-16.

9. *Lepidoscia heliochares*. ♂, Konini Rd, Titirangi AK, actinic trap, 3-4 Aug 2013 (NZAC). 10. *L. heliochares*. ♀, Kaitorete Spit MC, emg. 14 Aug 1998 from case under dead log (NZAC). 11. *L. heliochares*. ♀, Omapere ND, m.v. light, 21 Jul 2016 (NZAC). 12. *L. heliochares*. Larval cases, Kaitorete Spit MC, under dead log, 8 Aug 1998 (NZAC). 13. *Lepidoscia protorna*. ♂, Konini Rd, Titirangi AK, emg. 25 Jan 2016, from case found indoors (NZAC). 14. *L. protorna*. ♀, Rimutaka Place, Titirangi AK, m.v. light, 26 Jan 1999 (NZAC). 15. *L. protorna*. Larval case of male in fig. 13, coll. Dec. 2015 (NZAC). 16. *Lepidoscia* sp. near *lainodes*. ♂, Wright Rd, Albany AK, m.v. trap 13-14 Jul 2008 (NZAC).

Figs 17-24.

17. *L.* sp. near *lainodes*. ♂, Minnehaha Ave., Titirangi AK, actinic trap, 29-30 Jul 2001 (NZAC). 18. *L.* sp. near *lainodes*. ♀, Minnehaha Ave., Titirangi AK, emg. 7 Jul 1999, from case found on house wall (NZAC). 19. *L.* sp. near *lainodes*. Larval case of female in fig. 18, coll. Jun 1999. 20. *Glyphipterix simpliciella*. ♂, Ahu Ahu Track, Karekare AK, on *Leucanthemum vulgare*

flower, 11 Nov 2012 (NZAC). 21. *Coleophora deauratella*. ♂, Auckland University Tamaki campus, St Johns AK, by day, 10 Nov 2016 (NZAC). 22. *Opsitycha squalidella*. ♀, Kennedy Park, Napier HB, m.v. light, 29 Nov 2000 (NZAC). 23. *Philobota* sp. A. ♂, Ruakura WO, emg. 16 Oct 2012, reared pasture grasses (NZAC). 24. *P.* sp. A. ♀, Ruakura WO, emg. 12 Oct 2012, reared pasture grasses (NZAC).

Figs 25-32.
25. *Philobota chionoptera*. ♂, 7 miles E. of Captain's Flat, N.S.W., 2 Nov 1967 (ANIC). 26. *Tachystola hemisema*. ♂, Wright Rd, Albany AK, m.v. trap, 28-29 Mar 2015 (NZAC). 27. *T. hemisema*. ♀, Kepa Bush, Meadowbank AK, m.v. light, 27 Mar 2015 (NZAC). 28. *Depressaria radiella*. ♂, Port Chalmers DN, emg. Feb 2009, ex la. on *Pastinaca sativa* (NZAC). 29. *Microcolona* sp. A. ♂, Albert Park, Auckland City, AK, 30 Oct 2006 (NZAC). 30. *Cosmopterix attenuatella*. ♂, Te Paki (shearers' quarters) ND, m.v. light, 2 Nov 2007 (NZAC). 31. *Blastobasis marmorosella*. ♀, Princes St., Auckland City AK, on wall, 28 Nov 1988 (NZAC). 32. *Symmetrischema striatella*. ♂, Kamo Rd, Whangarei ND, lit window, 20 Apr 2012 (NZAC).

Figs 33-40.
33. *Platyedra subcinerea*. ♂, Russley, Christchurch MC, to light, 7 Nov 2015 (NHNZ). 34. *Isotenes miserana*. ♂, Kitenui Ave., Mt Albert AK, emg. 15 Aug 2007, ex la. in *Camellia* litter (NZAC). 35. *I. miserana*. ♀, Auckland University Tamaki campus, St Johns AK, 12 Feb 2014 (NZAC). 36. *Stericta carbonalis*. ♂, Lee's Springs, ACT, Australia, emg. 6 Nov 1967, reared dead leaves (ANIC). 37. *Stericta carbonalis*. ♀, Reynolds Valley Rd, Banks Peninsula MC, to light, 25 Jan 2010 (NZAC). 38. *Balanomis encyclia*. ♂, North Cape ND, emg. 3 Jan 2008, ex la. on *Cassytha paniculata* (NZAC). 39. *Ephestiopsis oenobarella*. ♀, Te Paki (shearers' quarters) ND, m.v. light, 2 Nov 2007 (NZAC). 40. *Aglossa pinguinalis*. ♀, Nelson NN, emg. 14 Dec 1965, reared from sheep manure (NZAC).

Figs 41-48.
41. *Musotima ochropteralis*. ♂, Devonport AK, emg. 10 May 2016, ex la. on *Adiantum capillus-veneris* (NZAC). 42. *Uresiphita ornithopteralis*. ♂, Mt Ragged, Western Australia, 1 Nov 1977 (ANIC). 43. *U. ornithopteralis* / *maorialis* (hybrid?). ♂, Rangiputa Reserve, Karikari Peninsula ND, m.v. light, 3 Nov 2007 (NZAC). 44. *U. ornithopteralis* / *maorialis* (hybrid?). ♀, Cutty Grass Tk, Waitakere Ra. AK, 21 Feb 2013 (NZAC). 45. *Uresiphita maorialis*. ♂, St Johns, Auckland, 20 Sep 2007 (NZAC). 46. *Sigilliclystis insigillata*. ♂, Wright Rd, Albany AK, m.v. trap, 10-11 Mar 2016 (NZAC). 47. *S. insigillata*. ♀, Hayden St., Freemans Bay AK, Heath trap, 31 Mar-1 Apr 2009 (NZAC). 48. *Ctenoplusia limbirena*. ♂, Wright Rd, Albany AK, m.v. trap, 6-7 Aug 2011 (NZAC).

Figs 49-56.
49. *Proteuxoa sanguinipuncta*. ♂, Blowhard Bush HB, m.v. light, 20 Feb 2007 (NZAC). 50. *P. sanguinipuncta*. ♀, Old Maori Track to Kaitawa, Lake Waikaremoana GB, m.v. light, 22 Feb 2007 (NZAC). 51. *Pantydia sparsa*. ♂, Paua, Parengarenga Harbour ND, m.v. light, 13 Oct 2008 (NZAC). 52. *P. sparsa*. ♀, Wright Rd, Albany AK, m.v. trap 14-15 Jan 2008 (NZAC). 53. *Stericta carbonalis*. Mid- to late-instar larva, April 2018, ex ovo from female, Reynolds Valley Rd, Little River, Banks Peninsula MC. 54-56. *Pantydia sparsa*. Larva (final instar), ex ovo from female to m.v. trap, Wright Rd, Albany AK, 28-29 Mar 2015.

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COVER

The dragonfly, *Hemicordulia australiae* (Rambur), in the wheel position near a garden pond at Currimundi, on the Queensland Sunshine Coast. This species is widespread in Australia, the Lesser Sundas and New Zealand. At the stage depicted the male (top) has previously transferred his sperm from the testes at the tip of the abdomen to the seminal vesicle on the second segment near the base of the abdomen. The female has made genital contact forming the heart-shaped 'wheel', during which the male inseminates her. Pen and ink drawing by *Australian Entomologist* subscriber, Dr Albert Orr, whose illustrated books on dragonflies and butterflies have won awards in Australia and overseas.

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